INDIA METEOROLOGICAL DEPARTMENT

NSTRUCTIONS TO OBSERVERS

AT THE

ECOND AND THIRD CLASS OBSERVATORIES

1930

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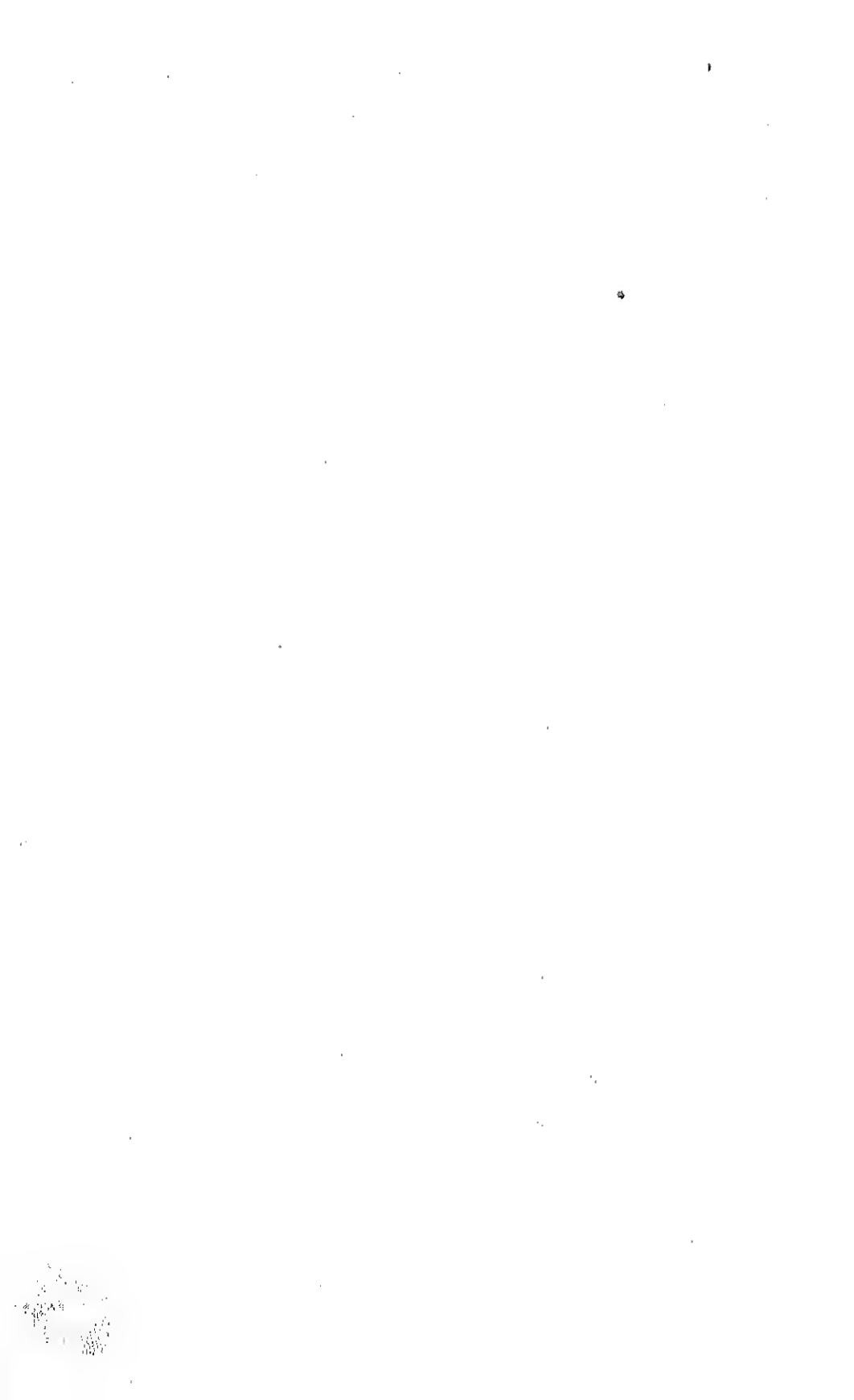
1930



FOREWORD.

This departmental hand-book, prepared by Dr. S. C. Roy, is intended for use by the Observers at second and third class observatories in India. The first four chapters should be very carefully read by each Observer and the instructions contained therein should be followed strictly in the daily observational work. The Meteorological Department will be glad to explain to the Observer any instructions that are not clear to him. He should also take every opportunity to discuss all doubtful points in the book with an Inspector when one visits his station.

This hand-book and the departmental cloud atlas together replace the old "Instructions to Observers", which is now out of print.

Poona,
May, 1930.

C. W. B. NORMAND,
Director General of Observatories.

ERRATA.

Page 26, line 22, For "If an anemometer" read "If, after the morning observations, an anemometer"

" 45, line 22, For "Give a small"... read "Give small" ...

" 50, line 5, For "upon generally level ground" read "on open and level ground".

" 50, line 8, Delete the words "covered with short grass".

" 50, line 16, For "shall be exactly 4 feet" read "shall be from 4' 3" to 4' 6".

" 54, line 30, (second line from bottom). Change full-stop to semi-colon and add: "this implies that there should be no object loftier than the wind instruments for a long distance (as far as possible) around".

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CHAPTER I.

INTRODUCTORY REMARKS.

1. CLASSIFICATION OF OBSERVATORIES.—The Observatories of the India Meteorological Department are of 4 classes :—

(*a*) **First Class** observatories are provided with eye-reading and self-recording instruments.

(*b*) **Second Class** observatories are furnished only with eye-reading instruments. Regular observations are taken twice daily and telegraphed to the different forecasting centres.

(*c*) **Third Class** observatories have the same instrumental equipment as the second class ones, but observations are taken only once a day and telegraphed to the different forecasting centres.

(*d*) **Other** observatories are either less equipped or are not required to telegraph the observations.

The majority of the Indian observatories belong to the second or the third class and it is chiefly for these observatories that this handbook is intended.

2. INSTRUMENTAL EQUIPMENT.—The basic instrumental equipment of a second or third class station is :—

(i) Mercury barometer.

(ii) Four thermometers—Dry bulb, Wet bulb, Maximum and Minimum erected in the Stevenson screen.

(iii) Raingauge.

(iv) Wind Instruments—Windvane and Anemometer.

3. METEOROLOGICAL ELEMENTS.—The meteorological elements which are to be observed at a second or third class station are stated below :—

(i) **Barometric pressure**, that is, the pressure of the air observed with the barometer.

(ii) **Dry bulb temperature**, that is, the temperature ofthe air inside the Stevenson screen at the time of observation.

(iii) **Wet bulb temperature**, which gives, in conjunction with the dry bulb temperature, the humidity of the air.

(iv) **Maximum temperature**, that is, the highest temperature reached by the air inside the Screen since the last setting of the maximum thermometer.

(v) **Minimum temperature**, that is, the lowest temperature reached by the air since the last setting of the minimum thermometer.

(vi) Amount of rain fallen between successive observations.

(vii) Direction and force of **wind** given by the Windvane and the Anemometer readings.

(viii) **Visibility** obtained by the observation of the ' visibility land marks '.

(ix) Amounts and forms of **cloud** and their directions of movement.

(x) Character of the **weather** since last observation and at the time of observation.

(xi) State of " **sea and swell** " (coast stations) or of **ground** (inland stations).

4. **HOURS OF OBSERVATIONS.**—

(i) **Regular hours** of observations at the second class stations are 8 hrs. local time and 17 hrs. Indian Standard Time (I.S.T.) At third class stations regular observations are taken only at 8 hrs. local time.

(ii) **Extra Observations** may be requisitioned at any hour by the various forecasting centres. The standard of time adopted for the special observations is always Indian Standard Time.

NOTE.—' **Indian Standard Time** ' is the time corresponding to long. 82½° distributed daily by telegraph line from the Madras Observatory and is kept at all Railways, and Post and Telegraph Offices. The clock or the watch that regulates the observations must be compared every day with the clocks of the Post and Telegraph Office.

5. **ORDER OF OBSERVATIONS.**—The barometer should be set and read *exactly* at the stated hours of observations, correct to a minute. The thermometers should be read next, in the order, dry bulb, wet bulb, maximum and minimum. Observations of the other elements should then follow the order, rainfall, wind, visibility, cloud, weather and state of sea or ground.

6. **OBSERVER'S DUTIES.**—The routine duties of an Observer are :—

(i) To make *regular* and *careful* observations *punctually* at the prescribed hours of observations.

(ii) To note the general character of the *weather* not only at the fixed hours of observations, but throughout the day, and to record anything unusual or remarkable, with the time of its occurrence.

(iii) To compare *each morning* the readings of the maximum and minimum thermometers with that of the dry bulb thermometer after setting them.

(iv) To prepare and despatch the *weather telegram*, marked 'XW', to the different forecasting centres, *immediately* after the observations are taken.

(v) To send out, promptly, **heavy rainfall telegrams** to the various officers on the warning list.

(vi) To take **extra observations** whenever requisitioned by any forecasting centre, and telegraph these observations 'XW' or 'XXW', as asked for.

(vii) To copy *in ink*, each day's observations into the *Monthly Meteorological Register* the *next day* and to maintain the *Weather Diary* regularly.

(viii) To post the *Monthly Meteorological Register* and *Weather Diary*, together with the carbon copies of weather telegrams of each month, to the Meteorological Office **before the 4th of the succeeding month.**

(ix) To prepare *yearly returns* of the stock of instruments and forward them to the Meteorological Office.

(x) To keep the instruments *clean* and *free from dust.*

(xi) To provide a competent substitute to take observations in his absence.

NOTE.—*The regular observer should train the deputy observer thoroughly. If the* deputy observer *is inefficient, the chances are that his mistakes will be counted against the regular observer.*

7. GENERAL INSTRUCTIONS REGARDING OBSERVATIONS—

(i) **Punctuality**: Punctuality is a matter of great importance in making meteorological observations. The Observer should take great care to ensure that the clock or the watch by which he is guided, keeps correct *Indian Standard Time.* To avoid delay and irregularity he should make it his business to be ready near the barometer a few minutes before the prescribed time of observations. The Observer should record in the

Pocket Register the *exact* hours and minutes at which the barometer is read. He should understand that it is a detectable deception to put on permanent record the reading of a barometer at, say, 8 h. 15 m. as the reading at 8 h.

(ii) Honesty : Every observation should be recorded *honestly* as read. In cases of doubt the observations should be repeated twice or thrice, until the observer is satisfied. If any observations are not taken, the spaces in the *Pocket Register* allotted for them should be left blank. The reason for the omission of readings must, however, be clearly stated. In no case, should concocted figures be inserted subsequently.

(iii) Immediate Entry of Observations : Each observation must be written down in the Pocket Register *immediately after it is taken.* The readings should *never* be jotted down on scraps of paper with the intention of copying them later on.

(iv) Check on Entry : *Check* each observation after noting it down in the *Pocket Register* to make sure that no mistake has been made.

8. GENERAL INSTRUCTIONS FOR THE CARE OF INSTRUMENTS—

(i) The positions of the instruments must never be changed, except under orders from the Meteorological Department.

(ii) When an instrument is out of order and the observer is unable to remedy its defect, the Meteorological Office should be informed immediately by a telegram.

(iii) Barometer is a very delicate instrument and must be handled with great care. The Observer should *in no circumstances* try to remedy any defect found in a barometer without instructions from the Meteorological Department.

(iv) The bottle attached to the wet bulb thermometer must always be filled with rain or distilled water. The muslin and thread should be renewed *once a fortnight in fine weather, once a week in dusty weather, and immediately after a duststorm.*

(v) Wind instruments should be cleaned and oiled *at least once a fortnight in dusty weather and once a month in the rainy season.*

(vi) Tall grass or shrubs should not be allowed to grow round the Raingange as these would vitiate its exposure.

CHAPTER II.

THE INSTRUMENTAL OBSERVATIONS AND THE CARE OF THE INSTRUMENTS.

9. INSTRUCTIONS FOR SETTING AND READING THE BAROMETER.—There are two types of barometers in use known as the Fortin barometer and the Kew pattern barometer. These are described in Section 30, page 46.

The mode of setting and reading a Fortin barometer is as follows :—

(i) **Attached Thermometer :** Read the thermometer attached to the barometer to the nearest degree, a minute or so before the time specified for the barometer observation, and enter the reading in column 3 of the *Pocket Register*. This should be done first because the Observer's presence near the instrument is likely to heat the attached thermometer more quickly than the mercury in the barometer tube.

(ii) **Gently tap** the cistern and the tube of the instrument two or three times with the *pads* of the fingers to prevent the mercury from adhering to the glass.

(iii) **Setting of the mercury surface in the cistern :** Raise the surface of the mercury in the cistern by screwing up the plunger at the base until the top of the *ivory point just touches its image in the clean mercury surface.* If the ivory point appears to press down upon the mercury surface and to form a little cup-like hollow, lower the mercury surface by unscrewing the plunger and then re-adjust the mercury level by screwing up the plunger *very slowly* until the tip of the ivory point and its image just meet.

(iv) **Setting of the Vernier :** Adjust the vernier by means of the milled-head screw on the right hand side till its lower edge is a tangent to the *convex* top of the mercury column, *i.e.*, the front and back edges of the vernier and the top of the mercury column must all lie in the same straight line. This can only be ascertained if the *eye of the Observer is at the same level as the topmost point of the mercury column.* (For sighting error see Fig. 3.) Thus when the vernier is correctly set the appearance of the top of the mercury and the vernier will be as in Fig. 1.

If the vernier appears to cut off part of the mercury as in Fig. 2, then it has been set too low and if the appearance is as in Fig. 3, then the vernier has been set too high.

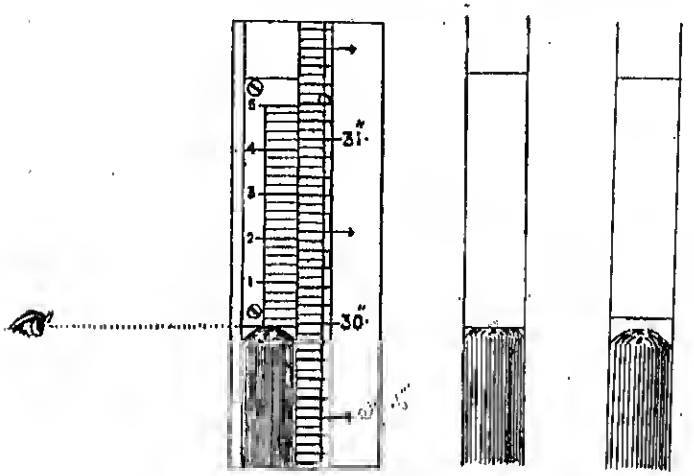


FIG. 1. FIG. 2. FIG. 3.

VERNIER SET CORRECTLY. TOO LOW. TOO HIGH.

A good plan for setting the vernier is as follows :—First place the vernier intentionally too high, so that a light space can be seen between the vernier and the top of the mercury column. Then lower the vernier very gradually so that this light space becomes less and less, and eventually the *lower edge of the vernier just touches the highest point of the mercury column.* No light space must be visible from any position of the eye between the edge of the vernier and the highest point of the curved mercury surface, but with the eye at the correct level (*see* Fig. 1) the *bright triangles on each side should appear as large as possible.*

(v) **Reading the Scale and the Vernier** : The fixed scale on the right of the vernier is graduated to 0·050 of an inch. First note between which two graduations the top of the mercury column stands and record the lower one. Thus in Fig. 1 the mercury top lies between 29·950″ and 30·000″ and hence the reading on the fixed scale should be taken as 29·950″. Then look along the vernier and see which of its lines most nearly coincides with a line on the fixed scale. Each division marked by figures 1, 2, 3, etc., on the vernier is equal to ·010″ and each sub-division between the figures is equal to ·002″

In Fig. 1 the third line above 3 of the vernier is continuous with a line on the fixed scale. The number 3 corresponds to ·030″ and the third sub-division corresponds to (3×0·002″) =·006″. Thus in the foregoing example (*see* Fig. 1),

Reading on scale	29·950″
Reading on Vernier	·030″
	·006″
Actual reading	29·980″

(vi) Enter in column 4 of the *Pocket Register* the actual reading of the barometer thus obtained.

(vii) Check the reading after entering it in the *Pocket Register* by making a fresh setting. Be very careful to avoid errors of ·05″, *i.e.*, error in counting the number of divisions on the fixed scale.

(viii) After each observation unscrew the plunger in the cistern so as to leave the mercury surface well below the ivory point. If this is not done the mercury and the ivory point will become dirty by prolonged contact with each other.

If the barometer is of the Kew pattern, no adjustment of the cistern has to be made, otherwise the instrument is set and read exactly as the Fortin.

10. BAROMETRIC CORRECTION AND REDUCTION.—The barometer reading has to be (*a*) corrected for index error (*i.e.*, an error inherent in the instrument) and temperature, and (*b*) reduced to standard gravity at latitude 45° and mean sea level. A **Barometer Correction Card** is supplied to each station to enable its Observer to apply corrections (*a*) and reduction (*b*). A specimen card of this type is reproduced on the next page.

Specimen Barometer Correction Card.

Station Multan. Lat. 30° 12′. Long. 71° 31′.
Height above M. S. L. 420 feet.

Bar. No. Casella Fortin 953. Index error +·018.

TABLE A.

Correction for temperature.

Attached thermometer.	Barometer Reading. 29·0″	29·5″	30·0″	30·5″
	Correction to be applied. *Subtract.*			
52°	— ·061	— ·062	— ·064	— ·064
54	·067	·068	·069	·070
56	·072	·073	·074	·075
58	·077	·078	·080	·081
60	·082	·084	·085	·086
62	·088	·089	·091	·092
64	·093	·095	·096	·098
66	·098	·100	·101	·103
68	·103	·105	·107	·109
70	·109	·110	·112	·114
72	·114	·116	·118	·120
74	·119	·121	·123	·125
76	·124	·126	·128	·130
78	·129	·132	·134	·136
80	·135	·137	·139	·142

TABLE B.

Reduction to latitude 45° and mean sea level.

Dry Bulb thermometer.	Barometer corrected for Temperature. 29·0″	29·2″	29·4″	29·6″	29·8″	30·0″	30·2″	30·4″
			Correction to be applied. *Add.*					
52°	+ ·404	+ ·407	+ ·410	+ ·412	+ ·415	+ ·418	+ ·421	+ ·423
54	·403	·406	·409	·411	·414	·417	·420	·422
56	·401	·404	·407	·409	·412	·415	·418	·420
58	·400	·403	·406	·408	·411	·414	·417	·419
60	·399	·402	·405	·407	·410	·413	·416	·418
62	·398	·401	·404	·406	·409	·412	·415	·417
64	·397	·400	·403	·405	·408	·411	·414	·416
66	·395	·398	·401	·403	·406	·409	·412	·414
68	·394	·397	·400	·402	·405	·408	·411	·413
70	·393	·396	·399	·401	·404	·407	·410	·412
72	·391	·394	·397	·399	·402	·405	·408	·410
74	·390	·393	·395	·398	·400	·403	·406	·408
76	·388	·391	·394	·396	·399	·402	·405	·407
78	·387	·390	·392	·395	·397	·400	·403	·405
80	·385	·388	·390	·393	·395	·398	·401	·403

The correction is to be added or subtracted according as the sign at the head of table is + or —. The temperature of the Attached Thermometer must be used always in Table A and Dry Bulb temperature in Table B. The following example will serve to illustrate the use of the card :—

Multan Bar No. 953.

Attached thermometer	62°
Dry bulb thermometer (Index correction applied) .	65°
Barometer as read (column 4 of the pocket register) .	20·036
Index error (as given on the top of the card) . .	+·018
The temperature correction corresponding to attached thermometer 62° and barometer reading 30·0 (from Table A)	—·001
∴ barometer corrected for index error and temperature	20·863
Enter therefore 20·863 in column 5 of the pocket register.	
Reduction to latitude 45° and mean sea level corresponding to dry bulb temperature 65° and corrected barometer 20·0 (Table B)	+·409
∴ barometer corrected for index error and temperature and reduced to latitude 45° and sea level . .	30·272
Enter 30·272 in column 6 of the pocket register.	

11. CARE OF THE BAROMETER—

(i) Great care must be exercised in handling the barometer. When touching the instrument care should be taken *not to displace it from the vertical.*

(ii) The instrument should be lightly dusted every day with a small soft brush. It should never be rubbed with cloth.

(iii) The chief defect to which mercury barometers are subject is the entry of air into the space above the mercury. If any *air bubble* is noticed in the barometer tube, the matter should immediately be reported to the Meteorological Office. The Observer must not try to remedy the defect himself.

(iv) A barometer is so placed that there is always good light for setting and reading the instrument but the sun should not shine on it directly. If the instrument is found to be exposed to the direct rays of the sun at any hour of the day, this fact should be intimated to the Meteorological Office.

(v) When taking special observations in the night, or if the natural illumination is insufficient to set the barometer during the day-time, illuminate the instrument with the lamp supplied to you. Do not place a lighted match or other naked light

behind the instrument, as this frequently leads to very inaccurate setting.

12. INSTRUCTIONS FOR READING THERMOMETERS.—The four thermometers, dry bulb, wet bulb, maximum and minimum, are exposed in a shelter of approved pattern called the Stevenson screen. (*See* Section 31, page 49.)

Hours of Reading and Setting.—The dry and wet bulb thermometers are to be read at *each* observation immediately after taking the barometer reading, but the maximum and minimum thermometers are to be read and set only *once* in 24 hours at the time of the *morning observation* (8 A.M. local time).

The following instructions should be followed carefully in taking thermometer readings :—

(i) **Order of Reading.**—Having let down the door of the Stevenson screen *first* read the dry bulb and wet bulb thermometers as *quickly* as is consistent with accuracy, so that they may not be heated by the presence of your body or by your breathing directly on the bulbs. Then read the maximum and minimum thermometers.

(ii) **What to observe.**—In the case of the dry bulb, wet bulb and the maximum thermometers observe the position of the end of the mercury column (*see* Fig. 4) ; but in the case of the minimum thermometer note the position of the end of the dumb-bell-shaped index *furthest from the bulb*. (*See* Fig. 5.)

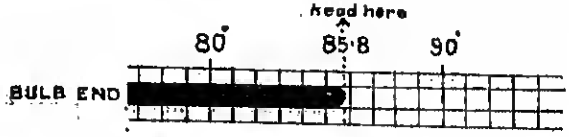


FIG. 4 MERCURY THERMOMETER.

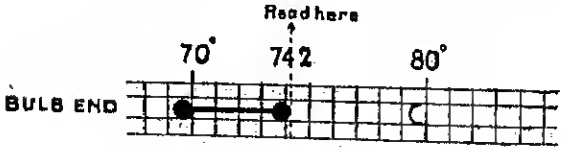


FIG. 5 MINIMUM THERMOMETER

(iii) **Degree of accuracy.**—Read all the thermometers to the nearest *tenth* of a degree. This can be done by dividing

mentally one degree into ten equal parts. Always use the graduations etched on the glass stem of the thermometers and not the bold graduations on the porcelain or metal plate on which the thermometer is mounted.

(iv) **Sighting Error.**—While taking a reading make sure that the straight line joining your eye to the end of the mercury column (or index in the case of minimum) is at right angles to the length of the column. Errors due to wrong sighting may easily amount to as much as ·5 of a degree. (*See* Fig. 6.)

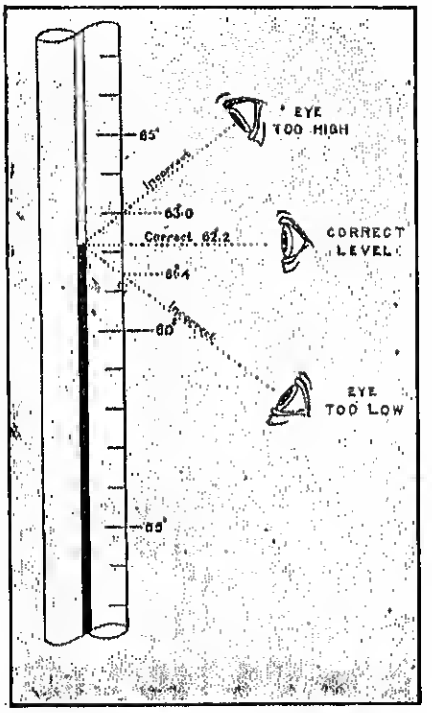


FIG. 6. SIGHTING ERROR.

(v) **Entry.**—Enter each reading in the appropriate column of the *Pocket Register immediately* after it is taken.

(vi) **Check.**—After making the entry *verify if the whole number of degrees has been read correctly.* Mistakes of ten or five whole degrees are sometimes made through not verifying the readings. The bold graduations on the thermometer mount is of help in this connection.

(vii) Setting.—As soon as the readings of the maximum and minimum thermometers have been noted and checked, set the thermometers ready for the next day's observations (*see* Sections 14 and 15).

(viii) Test Observations.—When set, the end of the mercury thread of the maximum thermometer and the end of the index of the minimum thermometer furthest from the bulb should indicate the same temperature as the dry bulb after instrumental correction. This check must be applied daily at the time of morning observations and the test readings entered in the appropriate columns 34, 35 and 36 of the *Pocket Register*.

(ix) Examination of wet bulb.—After setting the maximum and minimum thermometers and noting down the test readings, examine the *muslin* and the *wick* of the wet bulb and *fill its bottle* with water. Then close the door of the Stevenson screen.

NOTE.—*When observing by artificial light, take care not to heat the thermometer bulbs with the lamp.*

13. MOUNTING OF THE WET BULB THERMOMETER AND ITS CARE.—The dry bulb and wet bulb thermometers are precisely alike and have usually small bulbs which may be round or cylindrical. The bulb of the latter is always kept wet by means of a *muslin* sheath fed by water from a bottle through a *wick*.

(i) Mounting of the wet bulb thermometer :—The general arrangement of the thermometer wick and the water vessel is shown in Fig. 7.

The bulb of the thermometer should be covered with *only one* fold of thin and soft muslin supplied by the Meteorological Department. The muslin should be washed in boiling water to remove all the starch. If the bulb is round, cut a circular piece of muslin of about 1½ inch diameter and make a sort of bag out of it by pulling the fringes round the tip of a finger. For a cylindrical bulb take a rectangular piece and shape it in the form of a close-fitting sewn jacket. Then tie the muslin sheath round the neck of the bulb by a piece of thread. See that the muslin is stretched smoothly on the bulb. After fixing the muslin, trim its edges carefully with a pair of scissors so that all superfluous muslin with its loose ends is cut off ; but take care that the muslin extends at least 1/10th of an inch up the stem above the bulb.

For the *wick*, take *four* strands of darning cotton and loop it round the neck of the bulb *over the muslin* in the form of a noose (*see* Fig. 7) so that

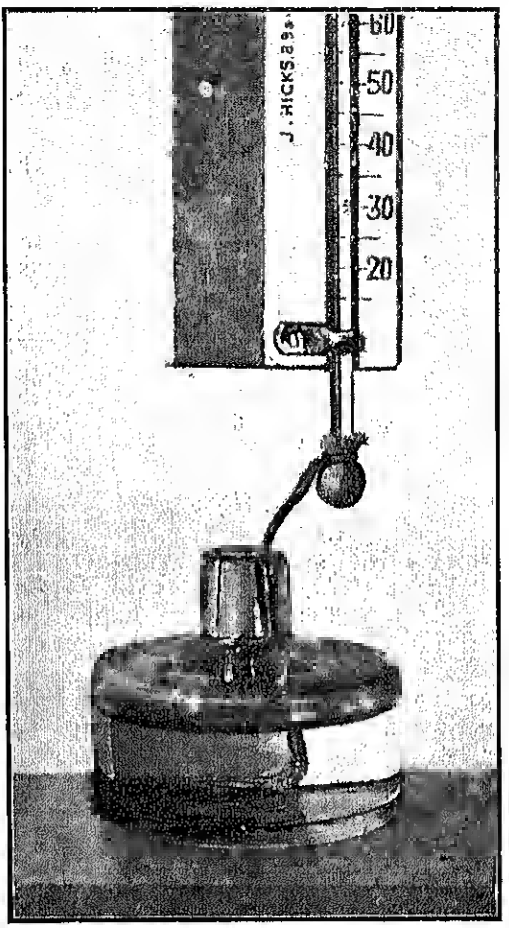


FIG. 7. MOUNTING OF WET-BULB THERMOMETER.

eight ends hang down into the bottle of water. Take care not to fasten the wick too tight round the neck of the bulb, or the circulation of the water along the strands will be checked at this point.

The bottle must be placed a little on one side of the wet bulb away from the dry bulb and *not directly below the wet bulb*; otherwise the thermometer may read too high. The part of the wick exposed to the air should be about four to six inches in length and must dip into the bottle without forming loops. If the wick is allowed to hang in a loop, water will dip

down from the lowest point of the loop and the bottle will soon be emptied. In no circumstances should the strands of the wick cover the bulb ; for there should be nothing touching the bulb but muslin.

(ii) **Care of the wet bulb thermometer.**—The bottle must always be kept free from dirt and filled with clean water. For this purpose the observer should store up rain-water in well-corked bottles. If for any reason the stock of rain-water is exhausted and ordinary water has to be used, it must be well boiled and then left for a few days to allow all its impurities to settle down. The use of ordinary water unless distilled or boiled causes a coating of hard crust on the bulb of the thermometer thus making its readings entirely unreliable. If a white deposit appears on the bulb of the thermometer, it should be removed by rubbing the bulb with vinegar or lemon juice. If the crust is thick dilute nitric acid should be used.

Both muslin and cotton must always be kept clean and free from grease. They should therefore be renewed *once a fortnight* in fine weather, *once a week* in dusty weather and *immediately* after a duststorm.

(iii) **Management of wet bulb during Frost.**—When the reading of the wet bulb thermometer is below 32°F, the freezing of the water on the wick cuts off the supply of moisture to the muslin. In this case, wet the muslin with ice-cold water by means of a feather about *half an hour* before the time of observation. If the wind is strong repeat the wetting once or twice until a thin film of ice forms on the muslin. Wait until the reading of the wet bulb falls *below* that of the dry bulb and no further fall of temperature is noticeable. Then take the reading. During prolonged frost, if the bulb has already a thin coating of ice from the previous observation, it is not necessary to renew the ice coating in later observations.

NOTE.—Before taking a reading of the wet bulb thermometer always make sure that it is *properly wetted*. In warm dry weather water evaporates rapidly from the wick and there is the danger of the muslin being left dry. On the other hand in damp cold weather, too much water may collect on the muslin and even drip down from the bulb. Both these defects make the reading of the wet bulb thermometer too high ; they should be avoided by adjusting the length of the wick exposed to air.

14. SETTING OF THE MAXIMUM THERMOMETER.—The bore in the stem of the Maximum Thermometer is made extremely fine near the neck of the bulb. When the temperature of the air rises, the mercury in the thermometer expands and forces its way into the stem past this constriction ; but when the bulb cools, none of the

mercury above the constriction can get back into the bulb and the length of the mercury thread remains just the same as it was when the bulb was warmest. The end of the mercury thread furthest from the bulb thus registers the maximum temperature reached.

To set the thermometer remove it from its supports and grasp (*see* Fig. 8) the upper end of its porcelain or wooden mount keeping the *bulb end downwards*, and taking care not to bring any pressure on the thermometer stem so as to break it. Then stretch out the arm and swing down the instrument *briskly* towards the feet describing a circular path in the air (as in the case of clinical thermometer).

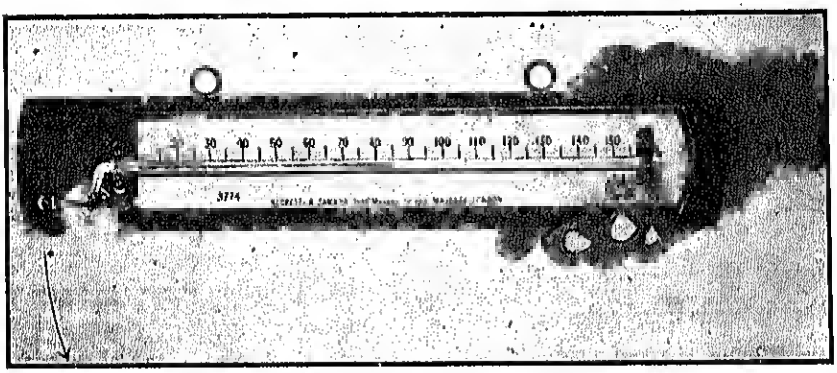


FIG. 8. SETTING MAXIMUM THERMOMETER.

While swinging the thermometer take your stand in a clear space so that the instrument may not strike any obstacle and get damaged. If necessary repeat the swingings once or twice until the thermometer bore on *both* sides of the constriction is filled with mercury. Then replace the instrument to its supports in the Stevenson screen keeping the *bulb end about quarter of an inch lower than the other end.* Verify if the thermometer reads nearly the same as the dry bulb. If not, the instrument must be reset.

NOTE.—Before reading a maximum thermometer it is well to make sure that the end of the mercury thread nearest the bulb has not *run away* from the point of constriction, through vibration or otherwise; if it has, the thermometer should be tilted very gently until the end of the detached thread comes in contact with the constriction in the tube.

15. SETTING OF THE MINIMUM THERMOMETER.—The liquid inside the *Minimum Thermometer* is *spirit* in which is immersed a dumb-

bell-shaped index. When the temperature falls, the spirit drags the index along with it towards the bulb end; but when the temperature rises the spirit expands and runs past the index without disturbing it. Thus the end of the index *furthest from the bulb* gives the lowest temperature attained by the instrument.

To set the minimum thermometer remove it from its supports and tilt it slowly, bulb upwards, until the index touches the end of the spirit column (*see* Fig. 9). Tap the instrument gently if necessary. Then

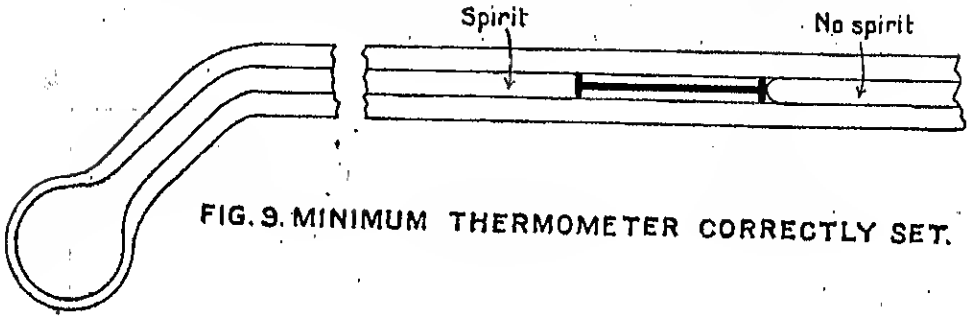


FIG. 9. MINIMUM THERMOMETER CORRECTLY SET.

mount the thermometer horizontally in the Stevenson screen and verify that it reads nearly the same as the dry bulb thermometer. See that the instrument is fixed properly to its supports so that the position of the index may not be disturbed by the vibration of the screen in strong winds.

NOTE.—Before reading the minimum thermometer *always examine the spirit column and make sure that there are no drops of spirit in the upper end of the tube and no air bubbles in the spirit column or in the bulb.* If the spirit column is broken or drops of spirit are lodged in the upper end of the stem, restore the column *at once* in accordance with the instructions given in Section 16. In such cases the remark "thermometer out of order" should be entered in the Pocket Register.

16. DEFECTS OF THERMOMETERS AND THEIR REMEDY.—

(i) **Restoration of Graduation Marks.**—The black markings of the thermometer graduations often become indistinct. To restore the markings rub lamp black and oil or a black "lead" pencil on the thermometer stem, which should be dry. Remove the superfluous black paint from the stem by gently wiping it with a piece of cloth.

(ii) **Mercury Thermometers Out of Order.**—A mercury thermometer, dry, wet or maximum, is out of order if the mercury

thread is broken anywhere. It is repaired simply by swinging the thermometer briskly at arm's length with the bulb end downwards (*see* Fig. 8) until the mercury thread is continuous.

(iii) **Defects of the Minimum Thermometer.—**

(*a*) *Drops of spirit lodged at the top.*—A portion of the spirit column may evaporate and condense in drops at the end of the thermometer furthest from the bulb. Unless the Observer regularly inspects the minimum thermometer, a length of 5 or 10 degrees of spirit may be lodged in this way at the top of the thermometer. To correct this defect, immerse the bulb and the *whole of the spirit column* of the thermometer, with the bulb end downwards, in a vessel of cold water; if necessary, add some powdered ice to the water bath. Allow the sun to shine * on the upper part of the thermometer in which the spirit drops are lodged but not on the water bath which should be screened from the sun's rays. Leave the thermometer immersed in the water bath in this upright position for about an hour to allow *all* the spirit to run down the tube.

(*b*) *Breaks in the Spirit Column.*—The spirit column of a minimum thermometer is sometimes broken into several fragments. To remedy this fault, swing the instrument *briskly* at arm's length (*see* Fig. 8) and stop it with a gentle jerk. It will sometimes be necessary to repeat the operation a great number of times entirely to unite the detached column. After reuniting the broken columns by swinging, keep the thermometer immersed in cold water for at least an hour exactly as in (*a*).

(*c*) *Index protruding out of the Spirit.*—The index is sometimes thrown out of the spirit and sticks in the upper part of the thermometer stem. In this case hold (*see* Fig. 10) the instrument vertically in the right hand with the bulb

* On a cloudy day the upper part of the stem should be heated by applying a piece of cloth soaked in hot water.

ond lowest and gently tap the lower end of the thermometer mount against the fleshy portion of tho palm of the left hand.

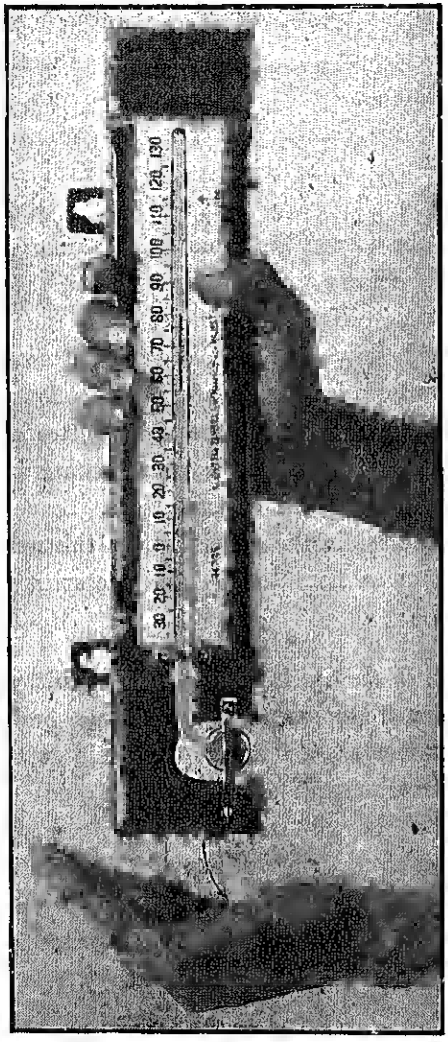


FIG. 10. RESTORING SPIRIT COLUMN OF MINIMUM THERMOMETER.

If several gentle taps fail to move the index, increase tho force, a little at a time, until the index starts; then allow the index to fall of its own weight within the continuous

column of spirit. Give gentle taps if necessary. Generally this will be all that is necessary to set the index in the right place. Sometimes broken columns of spirit can also be united partly or wholly by this process. If, however, repeated tappings do not succeed in displacing the index, turn the thermometer upside down so as to transfer the greater portion of the spirit column to the end furthest from the bulb. Then reverse the instrument and allow the index to fall to the lower end of the transferred column of spirit. Restore the spirit column by repeated swingings and finally keep the thermometer immersed in cold water for about an hour.

(*d*) *Index inside the bulb or stuck in the bend above the bulb.*—If the bulb and the stem are in the same straight line, simply raise the bulb until the thermometer is vertical. Then gently tap the instrument and the index will slide down into the tube.

If the thermometer is bent above the bulb, hold it *horizontally* with the *bulb pointing upwards*. Tap the bulb end of the thermometer sharply against the fleshy portion of your palm and then raise it upwards. The index will slide forward into the spirit column. Finally, leave the thermometer immersed in a cold bath as in (*a*).

(*e*) *Bubble in the bulb.*—In this case hold the thermometer horizontally so that the bubble is against the entrance of the tube, then warm the bulb by grasping it with your palm until the bubble rises in the tube. Then shake out the bubble by swinging and finally leave the thermometer immersed in cold water.

NOTE.—The minimum thermometer is very liable to the above faults during transit. Always examine the thermometer after taking delivery of it from the postman and remove any defects found in the thermometer in accordance with the foregoing instructions before bringing it into use.

17. MEASUREMENT OF RAINFALL.—The essential parts of a raingauge are (1) a *funnel* with an open circular mouth of known diameter, (2) a receiver in which rain falling on the funnel is collected and (3) a measuring glass with which the rain collected in the receiver is measured. For a full description of the raingauge *see* Section 32, page 50. The measure glass is graduated in hundredths of an inch

(cents) and has usually a capacity of ·50 inch (50 cents) of rain. Some stations are provided with bigger measure glasses which can hold one inch (100 cents) of rain.

(i) **To Measure the Rainfall.**—Remove the funnel of the rain-gauge and take out the receiver. Place the measure glass in a basin and slowly pour the contents of the receiver into the glass with care to avoid spilling. If however any water is spilled into the basin add it to the water in the measure glass before arriving at the total amount collected. Read the rain amount in cents with your *eye level with the water* surface in the glass.

(ii) **Measurement by Instalments.**—If the receiver contains more than half an inch of rain (or more than an inch of rain in the case of large glasses) measure it in two or more parts and add together the amounts. For instance, if the rain-water has filled a half-inch glass to the top mark 3 times and the remainder of the water measures 37 cents at the fourth filling, the rainfall is (0·50×3+0·37″), *i.e.*, 1·87″. *In actual practice the glass need not be filled exactly to the ·50″ mark as this can be done only by trials which require time. It is much quicker to fill the glass very near to the top graduation and keep a note at each filling.* For example the 1·87″ of rain might as well be measured as, say, (0·49″+0·46″+0·48″+0·44″).

(iii) **Remeasurement for Check.**—To avoid error the rain-water should not be thrown away after the first measurement, but should be poured into a vessel and afterwards remeasured. *The amount should always be written down in column 29 of the Pocket Register and checked by remeasurement before the water is thrown away.**

(iv) **Overflow of Rain-water.**—During heavy rain inspect the raingauge *at frequent intervals* and measure out the rainfall lest the receiver, which can hold only 3″ or 4″ of water, fill up and overflow. If rain-water *has* overflown into the lower half of the raingauge, the outer cylinder must be taken out and its contents measured and added to the amount in the receiver. The raingauge must then be reset and levelled.

* If your stock of rain-water for the wet bulb is not sufficient, store up more water in well-corked bottles [*see* Section 13 (ii)].

(v) **Snow or Hail.**—On days of snowfall or hail or when the water collected in the gauge is frozen, remove the receiver *with* the funnel and pour into it a *measured* amount of warm water to melt the solid precipitate. When all the snow or hail is completely melted, measure out the total amount of water in the receiver and subtract from it the amount of warm water added.

(vi) **Accidental Breakage of the measure Glass.**—Two measure glasses are usually provided to each station. As soon as a glass is broken ask the Meteorological Office *at once* to replace it by another. If it should so happen that the glass is accidentally broken and there is no spare, borrow an ordinary Compounder's measure glass and record the rainfall in ounces and drams until the broken glass is replaced. In such cases, take care to note in the *Pocket Register* the word "Ounces" against the rainfall entry. Do not, on any account, borrow a rain measuring glass belonging to another raingauge. If a Compounder's measure glass is not available, store up in separate bottles the rain-water collected at different hours of observations. Keep the bottles well corked and place a *label* on each giving the date and hour of collection of the rain-water. On the receipt of a new glass, measure these amounts and enter them in the *Pocket Register* as usual.

(vii) **Hours of Measurements and Entry of Rainfall in the Pocket Register.**—

(1) Examine the raingauge bottle daily both in the morning and the afternoon even though there has been no rain.

(2) Enter in column 20 of the *Pocket Register* the amount of rainfall measured at each observation. The entry should be made as follows :—0·00 for no rain ; 0·02″ for two cents ; 0·35″ for thirty-five cents ; 3·63″ for three inches and sixty-three cents ; 12·82″ for twelve inches and eighty-two cents ; and so on. For rainfall below one cent enter a "t" in this column. *Do not forget to write the decimal point distinctly and to insert 0 to the left of the decimal point when the rainfall is below one inch.*

(3) Remember that the entry in column 29 of the *Pocket Register* should give the amount of rain which actually fell during

the period beginning from the preceding hour of observation (regular or special) to the present hour of observation.

If during heavy rain it is found necessary to measure out the rain at intervals between any two hours of observation take the last measurement at the exact hour of the second observation and enter in column 29 the *total* of all the measurements made in the intervening period.

(viii) Care of the Raingauge.—

(1) See that the funnel does not get choked with dirt and that the inside of the receiver is clean.

(2) Occasionally examine if the funnel and receiver of the raingauge leak. If so, get them immediately repaired.

(3) While replacing the funnel make sure that it is pressed down evenly on the rim of the outer cylinder of the raingauge.

(4) The observer should be careful not to dent the rim of the funnel by rough handling.

(5) Do not allow long grass or shrubs to grow round the raingauge so as to vitiate its exposure; always keep them clipped short.

18. WIND DIRECTION.—The wind direction is to be read from the wind vane (Fig. 11) to the nearest of the sixteen points of the compass

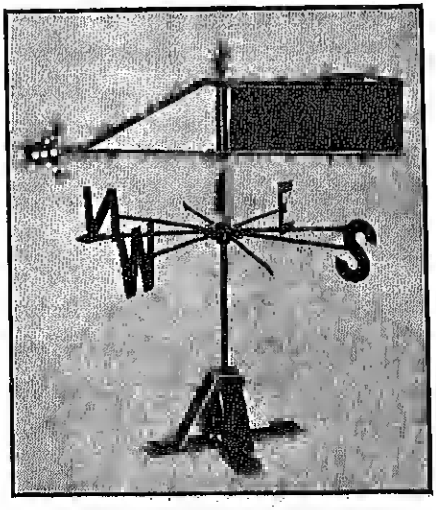


FIG. 11. WIND-VANE.

(see Fig. 12) given below :—

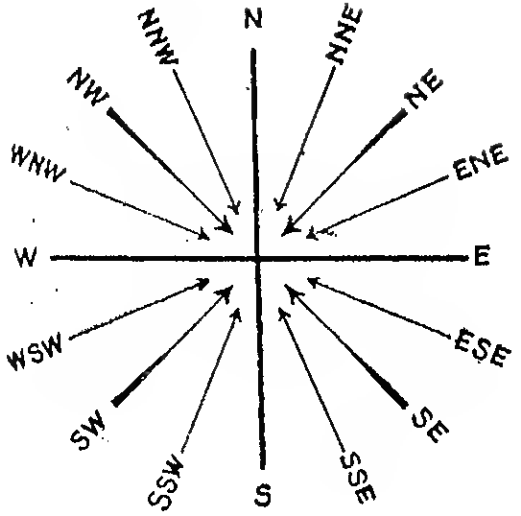


FIG. 12. POINTS OF THE COMPASS

North	N	South	S
North-north-east . .	NNE	South-south-west . .	SSW
North-east . . .	NE	South-west . . .	SW
East-north-east . .	ENE	West-south-west . .	WSW
East	E	West	W
East-south-east . .	ESE	West-north-west . .	WNW
South-east . . .	SE	North-west . . .	NW
South-south-east . .	SSE	North-north-west . .	NNW

(i) Note carefully that wind direction is always to be recorded as the point from which the wind comes.

(ii) The wind vane should be watched for a few minutes to get the mean direction of the wind.

(iii) Before taking a reading make sure that the wind vane moves freely. As ordinary wind vanes often fail to respond to light winds give a turn to the vane by hand and allow it to take up the direction of the wind.

(iv) If both the wind vane and the cups of the anemometer are motionless record the wind as "calm."

(v) Always verify if the wind direction given by the vane agrees with that estimated by you. In strong wind one can estimate its direction very closely by turning round and facing the direction

of maximum wind force. To estimate the direction of light winds, wet your finger and note which side of the finger feels coldest when it is held up. Also small bits of paper let off in the air will give you the approximate direction of the wind.

(vi) If the wind vane is *out of order*, note down in the *Pocket Register* the wind direction estimated as above.

19. WIND FORCE.—Hitherto Dial pattern anemometers were in use at the Indian observatories for the determination of wind speed. These are now being replaced by anemometers of the Cyclometer pattern described in Section 33. In this pattern the reading of the instrument is shown in figures. The range of the cyclometer is from 00000 to 99999. The four *black* figures to the left give the whole number of miles and the last figure which is *red* gives *tenths* of a mile. Thus in Fig. 13 the reading of the cyclometer is 1657·1 miles.

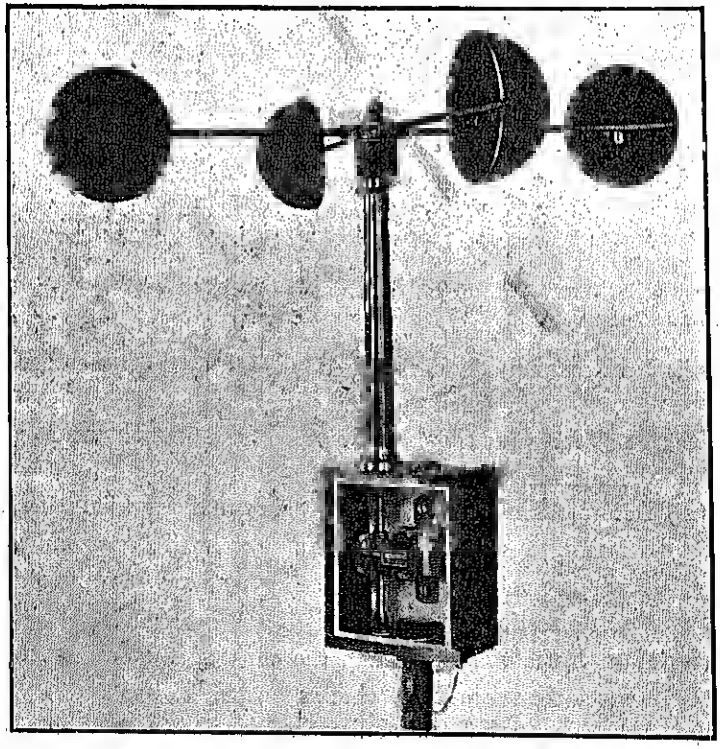


FIG. 13. CYCLOMETER PATTERN ANEMOMETER.

(i) Wind speed at the hour of Observation.—To determine the wind speed at the time of observation take two successive readings of the anemometer at an interval of three † minutes. Subtract the first reading from the second reading and multiply the difference by 20.

Example:

First anemometer reading	2090·9
Reading after 3 minutes	2093·1
Difference	2·2

Therefore the wind speed at the time is 44 miles per hour which is equivalent to force 9 on the Beaufort Scale set out below.

Specification of the Beaufort Scale of Wind Force.

Description of wind.	Beaufort Number.	Limits of speed Miles per hour.	Specification of scale to be used when anemometer is out of order.
Calm . . .	0	Less than 1	Calm; smoke rises vertically; leaves do not move.
Light air . .	1	2—3	Smoke bends from the vertical and drifts slowly with wind; wind vane not affected.
Light breeze . .	2	4—7	Wind just felt on face; leaves rustle; ordinary vane moved by wind.
Gentle breeze . .	3	8—11	Leaves and small branches in constant motion.
Moderate breeze .	4	12—16	Raises dust and loose paper; moves branches.
Fresh breeze . .	5	17—21	Crested wavelets form on lakes; trees in leaf begin to sway.
Strong breeze . .	6	22—27	Telegraph wires whistle; umbrellas used with difficulty.
Moderate gale . .	7	28—33	Whole trees in motion, inconvenience felt when walking against wind.
Fresh gale . .	8	34—40	Breaks small branches; difficulty experienced in walking against wind.
Strong gale . .	9	41—48	Slight structural damage occurs, especially to roofs.
Whole gale . .	10	49—56	Trees uprooted; considerable structural damage occurs, for instance kutcha houses blown down.
Storm . . .	11	57—65	Widespread damage.
Hurricane . . .	12	above 65	....

† In the case of Dial pattern anemometers, the interval is 4½ minutes.

NOTE.—After finding the wind speed from the anemometer readings, the observer should always compare it with his estimation of the wind force based on the observation of the effect of wind on the surrounding objects. This sort of comparison will enable the Observer to detect any arithmetical error in his calculation of the wind speed. If the anemometer is *out of order* or if the station is not equipped with an anemometer, report the wind force estimated according to the table above.

(ii) Average Wind speed during past 24 hours.—The average wind speed during the past 24 hours (which is to be calculated only at the time of the morning observation) is obtained by taking the difference in *whole miles* in the 8 hrs. readings of the two succeeding days and by referring to the *Average Wind Speed Table* supplied to each station. This is also given by the quotient obtained by dividing the difference by 24. If the remainder is more than 12 add 1 to the quotient.

Example :

Today's anemometer reading at 8 h.	0023·5
Yesterday's anemometer reading at 8 h. . . .	0832·6
Difference	100·9

The difference in whole miles is 191 approximately. Dividing this difference by 24, one gets 7 as quotient and 23 as remainder. Therefore the average speed during the 24 hours to be recorded is 8 miles per hour.

NOTE.—If an anemometer is taken down for repairs or oiling always note its reading after resetting the instrument. When calculating the average wind speed in the following morning, subtract from the 8 h. reading the reading recorded on the previous day after resetting the anemometer.

Example : Let the reading after resetting be 2566·2 at 10-30 A.M. and that on the following morning be 2672·6 at 8-30 A.M. The difference between the two readings is 106·4, *i.e.*, 106 approximately. The period between the two readings is (10-30 A.M. to 8-30 A.M.) 22 hours. Dividing 106 by 22 the quotient is 4 and the remainder is 16. Hence the average wind speed during the period is 5.

20. CARE OF THE WIND INSTRUMENTS.—The bearings of the wind instruments should be cleaned and oiled at least once a fortnight in dry dusty weather and once a month in the rainy season soon *after the morning observation.*

Wind vane.—Unscrew the top nut and remove the vane. Clean the head of the vane rod with a brush soaked in *kerosine* and put in a few drops of *clock oil* supplied by the Meteorological Department. Then replace the vane and the nut.

Anemometer.—The bearings and gear of the anemometer should be kept clean and properly lubricated.

Lubrication.—See Fig. 14. *Every week* put a drop or two of clock oil in the foot bearing (8) and in the worm (7). *Once every two months* fill the house of the top bearing (4) with cup-grease.

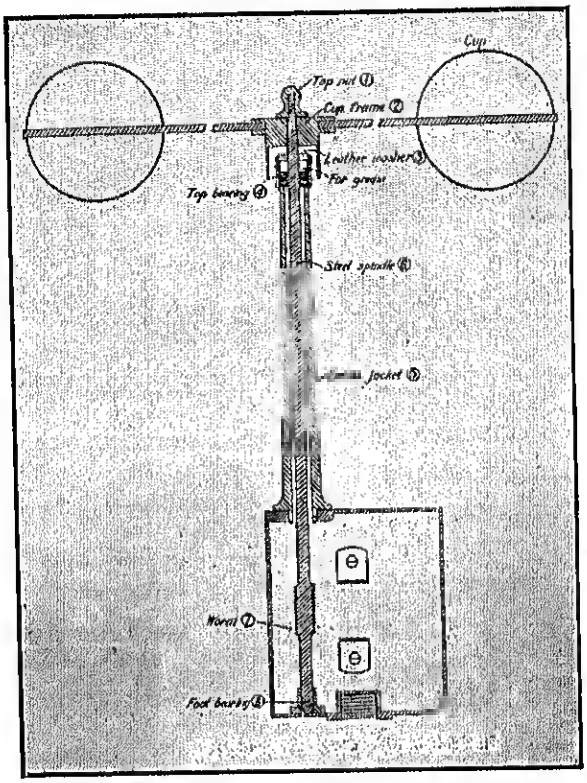


FIG. 14. ANEMOMETER IN SECTION.

Cleaning and overhauling.—*Once every six months* all parts of the instrument should be carefully examined and all the bearings thoroughly washed, cleaned and lubricated. Proceed as follows :—

(*a*) Remove the bottom screw chained to the box, and draw down the glass-front of the case.

(*b*) Unscrew the top nut (1), pull away the cup frame (2) and lift the leather washer (3).

(*c*) Unscrew the brass-jacket (5) of the spindle. The spindle (6) can now be easily drawn out of the box along with the jacket. *Do not try to remove the spindle from the jacket.*

(*d*) Wash with kerosine, the ball bearing (4), gear teeth (9) and the worm (7) and foot-bearing (8). The last consists of a single loose ball, and care should be taken not to lose it while cleaning.

(*e*) Wipe the parts dry with a piece of clean muslin and assemble them. Put a drop or two of clock oil in the worm (7), gear teeth (8) and the foot bearing (9) and fill the house of top bearing (4) with cup-grease.

NOTE.—After every operation of cleaning and overhauling, the reading of the cyclometer should be noted down as soon as the instrument is re-set.

CHAPTER III.

NON-INSTRUMENTAL OBSERVATIONS.

21. CLOUD OBSERVATIONS.—Cloud observations are to be made under three headings, *viz.*, (1) Form (*see Cloud Atlas*), (2) Amount and (3) Direction of motion.

(1) Cloud Forms.—The different forms of clouds are grouped in the following table according to their average heights.—

FORM.	AVERAGE HEIGHT IN FEET.
High Clouds (Above 25,000 ft.)	
Cirrus (C) Cirro-Stratus (CS) Cirro-Cumulus (CK)	30,000
Medium Clouds (Between 10,000 and 20,000 ft.)	
Alto-Cumulus (AK) Alto-Stratus (AS)	10,000—20,000
Low Clouds (Below 10,000 ft.)	
Strato-Cumulus (SK)	below 10,000
Nimbus (N)	(base) about 1,500
Cumulus or Fracto-Cumulus (K or FK)	(base) 4,500 (top) 6,000
Cumulus-Nimbus (KN)	(base) 4,500 (top) 10,000—25,000
Stratus or Fracto-Stratus (S or FS)	below 2,500

Below is given a brief description of the cloud forms for ready reference. For details the observer should always refer to the *Cloud Atlas*.

The transitions of the cloud formations are indicated tentatively under "growth" and "decay." It should be understood that these transformations involve a change of height as well as of form.

1. **Cirrus** (C).—Isolated feathery clouds, of fine fibrous texture, generally white in colour. It has often the appearance of "cats' whiskers" or "mares' tails."

Growth : Cirro-Stratus or Cirro-Cumulus.

Decay : Disappears.

2. **Cirro-Stratus** (CS).—Thin whitish sheet of cloud without shadows giving a milky appearance to the sky ("Cirrus Haze"). It has sometimes the appearance of a tangled web of short or of curling fibres matted together. It often produces haloes round the sun and moon.

Growth : Alto-Stratus.

Decay : Cirrus, or disappears.

3. **Cirro-Cumulus** (CK).—Small white balls or flakes of clouds without shadows or with very faint ones, arranged in groups or lines. They have often the appearance of a flock of sheep lying down, or, to the foam in the wake of a steamer. Its popular name is "Mackerel Sky."

Growth : Alto-Cumulus.

Decay : Cirrus, or disappears.

4. **Alto-Cumulus** (AK).—Large white or greyish balls with shaded portions, arranged in flocks or rows, often so close that edges meet. Alto-Cumulus is more flattened and disc-like than the typical Cumulus.

Growth : Cumulus or Strato-Cumulus.

Decay : Cirro-Cumulus.

5. **Alto-Stratus** (AS).—A thick sheet of grey or bluish colour without fibrous structure, bright near the sun or moon. It may produce coronas but not haloes. It appears often in the early morning and in winter.

Growth : Nimbus or Stratus.

Decay : Cirrus, or disappears.

6. **Strato-Cumulus** (SK).—Rolls of dark clouds, flat at the base, often covering the whole sky, and leaving only a little blue sky here and there seen through the breaks. It may be defined as Stratus thickened here and there into Cumulus, or Cumulus joined together with a common flat base to make a layer.

Growth : Nimbus (Cumuliformis).

Decay : Fracto-Cumulus.

7. Nimbus (N).—Rain cloud ; a dense layer of dark cloud without shape. Cirro-Stratus or Alto-Stratus are often visible through the openings of this cloud. Loose cloudlots drifting underneath a large Nimbus are known as " SCUD " (*Fracto-Nimbus*).

NOTE.—With the exception of the ordinary thundercloud which should be classed as *Cumulo-Nimbus*, any cloud sheet from which rain or snow is actually falling or threatens to fall, should be called *Nimbus*. *A continuous sheet of Nimbus and Alto-Stratus* should be distinguished as *Pallionimbus* from a bank of *Nimbus with vertical extensions* which should be called *Nimbus-Cumuliformis*.

Growth : Denser Nimbus.

Decay : Strato-Cumulus, Fracto-Cumulus or ' Scud.'

8. Cumulus (K).—Thick rounded lumps of cloud with the upper surface dome-shaped and bumpy, and the base usually horizontal. When viewed opposite the sun, they are white with dark centres. When viewed near the sun, they are dark with dazzling white edges. This form of cloud appears in greatest abundance during the warm part of the day and looks like exploded cotton bales (" Wool pack "). *Fracto-Cumulus* is the name given to Cumulus cloud which has been torn by high winds. It is a tattered, broken Cumulus.

Growth : Strato-Cumulus or Cumulo-Nimbus.

Decay : Alto-Cumulus.

9. Cumulo-Nimbus (KN).—Thundershower Cloud ; heavy masses of cloud rising like mountains, towers, or anvils. At the base is the dark formless Nimbus or drifting " Scud," from which showers of rain or snow are falling. At the top a cap of fibrous texture called " false Cirrus " is often seen. It is a detached cloud, but usually covers large areas.

Growth : Larger Cumulo-Nimbus.

Decay : Cumulus.

10. Stratus (S).—A low-lying horizontal cloud sheet of uniform thickness, having the appearance of a lifted fog. When this sheet is broken up into irregular shreds by wind or by tops of hills, it is called " Fracto-Stratus." The name Stratus should not be applied to the thin sheets commonly seen near the horizon about sunset. These are really high level clouds and should be classed as Alto-Stratus or Strato-Cumulus.

Transition forms { Fracto-Stratus, Strato-Cumulus or Alto-Stratus.

(ii) **Cloud Amount.**—Estimate the amounts of cloud of *each form separately* by the figures 0 to 10 in which 0 represents a sky quite free from cloud, 5 a sky half clouded, 7 a sky seven-tenths clouded, and 10 an entirely overcast sky. *Always see that the sum of the amounts of the different forms of cloud estimated separately, agrees with your independent estimation of the total amount of cloud irrespective of kind.*

(iii) **Entry of the Forms and Amounts of Cloud in the Pocket Register.**—Enter the amount and forms of low cloud in columns 22 and 23, those of medium or high cloud in columns 25 and 26, and the total amount of cloud in column 28. Always indicate the amount of each form of cloud *separately* by adding suffixes 1, 2, 3, etc., to the cloud symbols as shown in the following examples.—

Examples.—

(*a*) Suppose clouds present in the sky are—

Forms.	*Symbols.*	*Amounts.*
Alto-Cumulus (Medium)	AK	3
Cumulus (Low)	K	2
Cumulo-Nimbus (Low)	KN	4

Enter the amount of low cloud 6 in column 22 and the forms of low cloud as K_2, KN_4, in column 28; the amount of medium cloud 3 in column 25 and the form of medium cloud AK_3 in column 26; and the total amount of cloud 9 in column 28.

(*b*) Suppose clouds present in the sky are—

Forms.	*Symbols.*	*Amounts.*
Cirro-Cumulus (High)	CK	5
Cirro-Stratus (High)	CS	1
Alto-Cumulus (Medium)	AK	3
Alto-Stratus (Medium)	AS	1

Enter dashes " — " in columns 22 and 23 and the amount of medium and high cloud 10 in column 25; the forms of medium and high cloud $\frac{CK_5\ CS_1}{AK_3\ AS_1}$ in column 26; and the total amount of cloud 10 in column 28.

NOTE.—On occasions of fog, if the thickness of the fog is so great that it is impossible to tell whether there is cloud above it, the cloud should be entered in the Pocket Register as " Fog 10 " in the column for the amount of low cloud. If cloud can be seen through the fog, then the amount should be estimated as well as possible and entered in the ordinary way.

(iv) **Direction of motion of cloud.**—Ascertain the directions, nearest to the 8 points of the compass, from which the *predominant low cloud* and the *predominant medium or high cloud* are coming. To do so it is

best to observe the movement of the cloud against a fixed point. At night time when the cloud ceiling is broken, stars overhead form very suitable fixed points. At other times a steeple or a pole erected in an open space may be used. Take your stand vertically below the fixed point and resting your head against some support, watch for a few minutes the directions from which the clouds, overhead or nearly overhead, are drifting towards you. Enter the direction of the predominant low cloud in column 24 and that of the medium or high cloud in column 27 in letters such as N, NE, E, SE, etc.

22. STATE OF SKY AND EVOLUTION OF CLOUD.—No meteorological observation is more interesting and important than the study of the growth of clouds in the sky. The study will give the observer an insight into the sequence of weather in his locality in different seasons.

The sky is very seldom covered with cloud of one pure form. But the observer will find no difficulty in distinguishing between two principal types of clouds, (1) appearing in *sheets* such as Cirro-stratus, Alto-stratus and Pallio-nimbus, and (2) appearing in *heaps* such as Cirro-cumulus, Alto-cumulus, Cumulus and Cumulo-nimbus. He will also recognise that there is a *third* type of cloud, such as Strato-cumulus and Nimbus-Cumuliformis, which grow upwards in heaps but form extended sheets at the base. The course of evolution of clouds differs in different types of weather and varies from season to season in different localities.

For example, the observer will notice that during the hot season Stratus and Alto-Stratus which often appear in the morning, change to Strato-cumulus or Cumulus in the afternoon.

The types of weather which the observer should learn to distinguish from his study of the state of sky and the evolution of cloud, are—

1. Fine Weather.—Sky cloudless, or with fine isolated cirrus floating in the blue sky and showing signs of dissolving; or with pure stratus at a fixed level, but with no clouds of cumuliform origin (heap clouds).
2. Fair Weather.—Sky with fine and distinct cirrus covering a considerable part of the sky but not increasing or forming a continuous layer; or sky with 'fair weather cumulus' with characteristic changes in the course of the day.

NOTE.—'Fair Weather Cumulus' is often seen to appear in patches in the afternoon which instead of developing into cumulo-nimbus disappear in the evening.

3. **Unsettled Weather.**—Sky with alto-stratus or alto-cumulus cloud, evolved by the thickening of cirrus through the intermediate stages of cirro-stratus or cirro-cumulus but not originated by the clearing of nimbus or by the thinning of local cumulus or cumulo-nimbus.

4. **Changeable Weather.**—Sky characterised by rapid alterations in threatening appearances (large cumulus or cumulo-nimbus and possibly *debris* of medium clouds) and marked clearings.

5. **General bad Weather.**—Sky overcast with a thick veil of *pallio-nimbus* or *nimbus-cumuliformis* and showing no sign of clearing.

6. **Thundery Sky.**—Sky with threatening thunder clouds or heap-clouds in the form of *turrets, towers* or *anvils*.

23. **WEATHER REMARKS.**—One of the most important duties of an Observer is to note carefully in the "Remarks" columns of the *Pocket Register* the occurrence of weather phenomena such as gale, squall, hail-storm, thunderstorm, duststorm, dusthaze, fog, dew, frost, snow, etc., with the *duration* and *intensity* of such phenomena. Useful information such as sudden wind shift, the size of big hailstones, the estimated maximum force of gales, etc., should also be recorded.

To economise space and also to ensure uniformity in practice, the *symbols* given below should be used in entering "Weather remarks" in the *Pocket Register*. The symbols also indicate the character of the phenomena to which special attention should be directed.

(i) Explanation of the Phenomena and their Symbols.

1. **Wind.**

ϙ *Squall.*—A sudden increase of wind to force 7 or more, lasting for at least one minute. Squalls are of frequent occurrence during cyclonic storms or heavy local storms such as duststorms and thunderstorms.

Q *Line Squall.*—A violent squall, associated with the passing of a long line or arch of dark cloud and accompanied by thunder and lightning, rain or hail and a sudden cooling with a *shift in wind direction*. Such short bursts of violent winds are known to occur in Nor'wester ("Kal

Baisakhi ") of Bengal during spring and summer. A line squall, although of short duration, may blow down trees, houses, etc.

Gale.—Wind of force 8 or above, blowing *continuously* and doing damage to trees, houses, etc.

Duststorm.—The air is full of sand or dust driven by *strong winds blowing continuously*. The visibility is so bad that objects at a distance of 1,100 yards are not visible. A *short and sudden burst of violent winds* driving dust or sand in a line is called a *haboob* or a line-squall of dust. Duststorms must not be confused with small whirls of dust (*Dust devils*) which are seen almost daily on the plains of India during the summer months.

2. **Electrical Phenomena.**

Lightning.—Lightning seen but no thunder heard.

Thunder.—Thunder heard but no lightning seen.

Thunderstorm.—Thunder heard and lightning seen.

3. **Precipitation.**

Showers.—Precipitation lasting for a short time with bright intervals. Showery precipitation must be carefully distinguished from intermittent precipitation. The former occurs from passing clouds while the latter occurs from a dull overcast sky.

Drizzle.—Intermittent.

Drizzle.—Continuous.

Rain.—Intermittent.

Rain.—Continuous.

Snow.—Intermittent. } Precipitation in the form of white
Snow.—Continuous. } flakes.

Sleet.—(Rain and snow together.)

Soft Hail.—(Small pellets of *compacted snow* which usually fall in the hills.)

▲ *Hail.*—(*Pellets of ice* occasionally of considerable size.)

4. Atmospheric Obscurity.

≡ *Fog or Mist.*—A lowering of the transparency of the air caused by water particles in suspension. Whenever fog occurs, the winds are usually light and the relative humidity very high, at least 90 per cent. A very thin fog is called *mist*.

∞ *Haze.*—A lowering of the transparency of the air owing to the presence of fine particles of dust or smoke although there is no strong wind. In the case of a dust haze, the percentage of moisture in the air is usually very low.

NOTE.—Fog or Mist or Dust Haze are to be reported only when the visibility is less than 1¼ miles. *E.g.*, mist should be reported when objects are indistinct but traffic by road or rail is not impeded; if the obscurity is thick enough to interfere with traffic, fog should be reported.

V Unusually good visibility.

5. Ground Phenomena.

⌓ *Dew.*—Moisture condensed in the morning on exposed surfaces (metal roofs, grass, plants, etc.) owing to the cooling of the ground at night.

⌓ *Frost.*—Frozen dew, or water frozen hard in the crevices of the exposed ground. A frost is said to be *light* when it does not cause damage to vegetation. It is *moderate* when it injures the tender plants but not the staple products of the locality such as wheat, oat, paddy, cotton, etc. A frost is said to be *killing* when it damages the staple products.

6. Optical Phenomena.

◑ *Solar Halo.*—A ring of light round the sun as centre when thin cloud (Cirrus haze) veils the sky. It is often white but sometimes red near the sun, then orange, then yellow. The most common halo has a luminous ring of about 22° radius round the sun.

⊕ *Solar Corona.*—A ring of light much *smaller* than the halo. Its inner edge is brownish red while the sky between the

ring and the sun has a distinct bluish white colour. The radius of the coloured ring of a corona is usually about 5°.

Ψ *Lunar Halo.*—A ring round the moon similar to the Solar Halo.

Ψ *Lunar Corona.*—Similar to the Solar Corona.

 *Rainbow.*

(ii) Intensity.—Great intensity of the phenomena in (1), (2), (3) and (4) is represented by giving one dash below the symbols; moderate intensity is represented by the symbols themselves; whereas slight intensity is indicated by the exponent "°" written after and above the corresponding symbols. Thus,

=Severe duststorm.

=Moderate Thunderstorm.

=Intermittent thin drizzle.

=Heavy continuous rain.

=Moderate continuous rain.

=Slight continuous rain.

=Intermittent heavy snow.

=Slight Hail.

=Moderate Hail.

=Heavy Hail.

(iii) *Showery* precipitation should be indicated by prefixing the symbol ∇ before the precipitation symbols. Thus,

=Heavy rain shower.

=Light rain shower.

=Heavy sleet shower.

=Moderate snow shower.

24. VISIBILITY.—With the extension of aviation in India the necessity for accurate observation of visibility is being keenly felt. The table below sets out the distances of visibility landmarks and the determination of the most distant object of the series visible from an observatory on any given occasion constitutes visibility observation.

Visibility.—Fog, Mist, Duststorm and Hazo.

Standard distance of object.	List of Visibility Object.		Scale of Visibility.		
	Actual Distance.	Description of object.	Specification.	Description.	Symbol.
55 yards	.....	A.....	A not visible	Dense fog or dust-storm.	f or ≡
220 „	.....	B.....	A visible but not B.	Thick fog or dust-storm.	
550 „	.....	C.....	B visible but not C.	Moderate fog or dust-storm, or thick dust haze.	f or ≡S or ∞
1100 „	.....	D.....	C visible but not D.	Slight fog or dust-storm or moderate dust haze.	f° or ≡S° or ∞
1¼ miles	.....	E.....	D visible but not E.	Mist or slight haze, very poor visibility.	m or ∞
2½ „	.....	F.....	E visible but not F.	Poor visibility	..
6½ „	.....	G.....	F visible but not G.	Moderate visibility	..
12½ „	.....	H.....	G visible but not H.	Good visibility	..
31 „	.....	I.....	H visible but not I.	Very good visibility	..
			I or more visible	Excellent visibility	..

(i) Moteoroiogical Convention regarding Visibility.—An object is to be regarded as " visible " if it can be distinguished by eye ; if the object is a tree and it can be distinguished as a tree, it is to be noted as visible. It is often possible to see that there is " something " without being able to discern what it is, unless one knows beforehand its identity ; in such cases the object is not visible according to the above convention.

(ii) " Gaps " in the scale of " Visibility " objects.—At some stations, a complete set of landmarks corresponding to the visibility scale is not available. In such cases the Observer should try to *estimate* the distance of the furthest missing object which would have been visible if it had existed. The method of estimation is as follows.—Assuming there are objects E and G but no object for F, and that E is very clearly seen but G is invisible, then the visibility should be entered as 6 if the Observer thinks that F would have been visible if it were available. Again, if the available objects ended at G and on a particular occasion this object was visible with extreme clearness, the Observer should enter visibility as 8

if he considered that an object about 12 miles away would be visible or as 9 if he judged that one about 30 miles away would be visible, his estimates depending on the clearness of the atmosphere.

(iii) **Fog or Mist, Duststorm and Haze.**—The transparency of the air is reduced by the presence of dust or smoke particles in the air (duststorm, dusthaze or smokehaze) or by the presence of rain or drizzle or fog particles. If on any occasion the 'visibility' is 4 or less, the Observer must note if the atmospheric obscurity is due to fog or mist, duststorm or haze. He should also record the intensity of the phenomenon in accordance with the description of the scale of "visibility" laid down in the foregoing table. *Fog or mist, duststorm or haze must not be reported unless visibility is 4 or less.*

(iv) **Night "Visibility."**—The Observer may be asked to take observations in the night. The estimation of 'visibility' at night presents difficulties because it is not possible to get a selection of fixed standard lamps at the appropriate distances. The descriptions of the scale of visibility will, however, enable the Observer to estimate correctly the visibilities from 0 to 4. For the estimation of the visibilities from 5 to 9 the Observer should make use of his personal knowledge of any fixed lights in his locality at known distances. Apart from the use of lights a careful Observer can derive a considerable amount of information as to night visibility from a general inspection of the sky and his surroundings. It is surprising how much can be seen even on a fairly dark night, *e.g.*, a distant tower, a range of hills or a long road can often be recognised in circumstances which indicate that in daylight an object at that distance would have been visible. Experience will thus teach the Observer to make approximate estimation of night visibilities from a general inspection of his surroundings. One point which should be carefully remembered in the estimation of night visibility is that a cloudy night when the stars or the moon are obscured does not necessarily mean a night of bad visibility. Remember that visibility can be less than 5 only when dust or smoke or condensed water particles are present in the air.

25. STATE OF GROUND.—

Code No.	
0	Dry ground.
1	Dew (wet grass but not wet ground).
2	Wet ground.
3	Soft muddy ground.
4	Slight flood in the neighbourhood.
5	Moderate flood in the neighbourhood.
6	Severe flood in the neighbourhood.
7	Ground frozen (frost).
8	Ground covered by thin layer of hail or snow.
9	Ground covered by moderate or thick layer of hail or snow.

Observatories at or near aerodromes will report the state of the aeroplane landing ground. Other inland observatories will report the state of a suitable plot of ground selected by the Meteorological Department. The selected ground should be examined at each hour of observation and the code figure which most nearly describes its condition entered in the *Pocket Register.*

If the aeroplane landing ground is flooded or covered by hail or snow, the depth must be determined by plunging a scale vertically into the flood water or into the layer of hail or snow. In the case of other stations the depth of snow or hail lying on the selected ground need only be noted.

26. STATE OF SEA AND SWELL.—Coast stations have to report the state of the sea, *i.e.*, whether it is smooth, slight, moderate, rough, very rough or tremendous. The character and the direction of swell, if present, should also be reported. The Observer is to note carefully the distinction between *sea and swell. Waves* set up by *winds prevailing at the locality at the time of observation* are termed sea. *Rhythmic undulations* caused either by *winds at a distance from the place of observation, or by winds which have persisted in the locality previous to the time of observation,* are called swell. When a disturbance is once set up in the ocean it continues for a considerable time after the originating cause has ceased or passed away. Series of regular undulations often travel as *swell* beyond the limits of the wind which raised them; and may ultimately appear as rollers or breakers on shores far distant from their place of origin.

Swells may be classed into four groups according to their characteristics.—

A *Short Swell* means a Swell where the distance between each successive top of swell is small.

A *Long Swell* means a Swell where the distance is large.

A *Low Swell* means a Swell where the height between the lowest and highest part of the swell is small.

A *Heavy Swell* means a Swell where the height is great.

CHAPTER IV.

WEATHER TELEGRAMS AND REGISTERS.

27. POCKET REGISTER.—Detailed instructions for entering observations in the *Pocket Register* are given on pp. 11-16 of the Register. The following general remarks should, however, be carefully borne in mind.

The entries in the *Pocket Register* should be made *neatly in "lead" pencil with a fine point*. For this purpose always keep a *semi-hard* (HB.) pencil well sharpened and always in readiness in the pocket provided on the side of the cover of the Register. It is a very good plan to put an elastic band over each end of the *Pocket Register*, as by that means it can be opened at once at the right place, and in wet weather the other leaves will not be wetted by rain or the figures smudged.

Each observation must be written down *immediately after it is taken*. The readings should *never* be jotted down on scraps of paper with the intention of copying them in later on.

The *Pocket Register* constitutes the original source, to which reference must be made in cases of doubt, and it is therefore essential that there should be no ambiguity about the entries and that their meaning should be clear without reference to the Observer who made them. The entries should in no circumstances be mutilated or erased ; a wrong entry should be crossed through with one line only and the correct reading re-entered legibly. Doubtful entries should be marked with a query (?).

Omissions of observations mean a break in the continuity of a valuable record, and must be avoided. It is therefore necessary to have a well-trained deputy to take observations in the absence of the Observer. If,

however, any observation is missed owing to unavoidable reasons, the words "No Obs." should be written in the corresponding column.

Punctuality is of the greatest importance. Should the observations be taken more than 10 minutes earlier or later than the fixed hour, a note to that effect should be made in the margin.

The *Pocket Register* should also contain records of all changes in the instruments and of the times when they are cleaned or adjusted.

In addition to the observations at fixed hours, the occurrence of such phenomena as squall, gale, hailstorm, thunderstorm, duststorm, fog, rain, etc., should be noted in the 'Remarks' columns with times of commencement and cessation. *The Standard of time adopted must always be I. S. T.*

The *Pocket Register* contains forms to last for about a year. *It must be forwarded to the Meteorological Department as soon as all the forms are filled in.*

28. WEATHER TELEGRAM.—Full instructions are given in the "*Weather Message Code*" for the preparation of the weather telegram from the observations recorded in the *Pocket Register*.

The Observer must prepare and despatch the *telegram immediately after taking a set of observations*. Always *check* the telegram before sending it to the Telegraph Office. A *carbon copy* of each weather telegram must be kept by the Observer and forwarded to the Meteorological Department, at the end of the month along with the *Monthly Meteorological Register*.

The regular 8 hrs. weather telegram should be sent to one or more of the following addresses according to standing orders :—

WEATHER :—

Poona, Karachi, New Delhi, Peshawar, Quetta, Madras, Alipore (Calcutta), and Rangoon.

The regular 17 hrs. weather telegrams should be sent to one or more of the following addresses according to standing orders :—

WEATHER :—

Karachi, New Delhi, Alipore (Calcutta), Rangoon and Quetta.

Class all regular morning and afternoon weather telegrams 'XW' and special weather telegrams 'XW' or 'XXW' as required.

Any *voluntary weather telegram giving information in plain language* about the occurrence of gales and severe local storms such as Nor'westers, unusual hail or thunder or duststorms, etc., is always appreciated and rewarded according to the merit of the message.

29. MONTHLY METEOROLOGICAL REGISTER AND WEATHER DIARY.—Each day's regular observations recorded in the *Pocket Register* should be copied in ***black ink*** in the *Monthly Meteorological Register* the *next day*. While copying, special care should be taken to put down corresponding figures (Units, Tens, Hundreds, etc.) *vertically* under each other so that the columns can be added up easily at the end of the month. The position of the decimal point must also be *clearly* shewn in each entry. Queries appended in the *Pocket Register* to doubtful readings should be copied in the *Monthly Register*. To avoid errors in copying, each entry in the *Monthly Register* should be *checked* by reading against the original *immediately* after the entry is made and *also* at the end of the month before adding the columns.

The *Weather Diary* is a more detailed description of the course of weather and the appearance of the sky than what is given in symbols in the " Weather Remarks " columns. The *Weather Diary* should be neatly written out in *plain language*. As the name implies the diary should be filled up *daily*. If the weather is fine or fair record it as such. In the case of disturbed weather describe fully, but briefly, the sequence of events preceding and following such weather. Below are given examples of what may be done by an Observer whose opportunities are limited by indoor occupation :—

(i) 29th Feb. : Early morning, warmer than usual. Overcast ; continuous light to moderate rain from 6-30 A.M. to 9 A.M. Forenoon, sky cleared considerably. At 12-10 P.M. dark clouds came thickly over and wind changed rather suddenly from SW to WNW and air became cooler. Sky became less dark in about 25 minutes but day remained gloomy and showery until sunset after which sky cleared.

(ii) 18th May : Cirrus appeared early noon, changed to Cumulo-Nimbus by afternoon. Severe duststorm occurred between 4 and 4-30 P.M. followed by thunder and rain up to 5-30 P.M.

(iii) 1st Nov. : Sky overcast and drizzling since early morning, moderate rain began at 10-10 A.M. Wind and rain began to increase and weather became worse and worse with progress of the day. At 4 P.M. trees began to rock to and fro and telegraph line in front of Collector's Office gave way. At 5-30 P.M. virulence of wind became unbearable and from 6 to

7 P.M. no one could get out. Between 7 and 7-30 P.M. there was a lull in the storm for about 15 minutes. There was no rain or wind during the lull and sky was practically clear. Wind, before the lull, came from NNW ; immediately after the lull violent winds blow from SSE. Storm after the lull was worse than storm before it. Occasional flashes of lightning could be seen but thunder could not be heard as the wind seemed to muffle the noise of the thunder.

(iv) 11th April : Practically clear sky up to noon when some Cumuliform clouds appeared in the sky. Air was practically calm with occasionally light southeasterly breeze. It became extremely sultry in the afternoon. A huge Cumulo-Nimbus grew in the western horizon at about 5-30 P.M. and began to spread on all sides. A bank of black clouds came over at 6-20 P.M. followed by rolls of thunder and lightning. Violent cold northwesterly winds started *suddenly* lasted for about 12 minutes and pulled down many trees and kutcha houses. A terrible hail storm followed, lasting for about 15 minutes. Then moderate to light rain continued up to 8-30 P.M. after which sky gradually cleared. Some of the hailstones were more than two inches in diameter. Depth of the layer of hailstones collected in the ground near raingauge was about five inches.

The "*Monthly Meteorological Register and Weather Diary*" must be completed and forwarded to the Meteorological Office *immediately* after the end of the month and *in no case later than the 4th* of the following month. The Observer will, therefore, find that strict observance of the *system of writing out the Monthly Register day by day is extremely advantageous.*

At the end of each month, the Observer has to add up the columns of the "*Monthly Register*" and work out the *means*. The addition may be much simplified by taking some number as constant to the left of the decimal point. For instance, in the case of the barometer columns it will be readily seen which is the most frequent number, 29 or 30 (at low level stations) ; if 29 is taken as constant, it will be necessary only to add up the figures to the right of the decimal and then add 1 to this total for every inch above 29, and subtract 1 for every inch below 29.

Example : Suppose that the sum of the figures to the right of the decimal amount to 21·048, and to the left of the decimal 30 occurs 7 times and 28 occurs 3

times, the other values being 29; then, by adding 7 for the 30″ and deducting 3 for the 28″ the following result is obtained: (7 – 3)+21·648=25·648. This would, therefore, be the *sum* for the barometer column, taking 29″ as constant. Dividing this total by 31, which is presumed to be the number of days in the month, and adding 29″, the *mean* is 29·827″.

The same method may be employed in adding up the dry, wet, maximum and minimum thermometers.

The Observer should add up the columns *twice*, first *upwards* and then *downwards*; so that if a mistake be made one way, it will most probably be found out the other way. In dividing the sums to obtain the means, the *last figure of the quotient should always be increased by one if the remainder be one half or more of the divisor.*

The Observer should remember that the "*Monthly Meteorological Register and Weather Diary*" is intended to be a permanent record and must, therefore, be complete in itself. All *blanks* in it must be scrupulously filled in. The entry of the position of station, its height above mean sea level, the hours of observations, etc., must be *repeated* on each sheet.

CHAPTER V.

EXPOSURE AND ERECTION OF INSTRUMENTS.

30. BAROMETER.—The essential parts of a barometer are:—(1) a *glass tube* of about 35 inches length closed at the top and open below, (2) a cup or *cistern* and (3) a brass *scale*. The glass tube is filled with mercury and its open end is dipped in the mercury in the cistern which prevents air entering the tube. Above the mercury column in the barometer tube is an empty space and great care is taken to *exclude from this vacuum all air, as its presence, even in extremely minute quantities, will vitiate the readings of the instrument.* The mercury column in the tube is supported by the pressure of the air on the surface of the mercury in the cistern.

As the mercury in the barometer tube rises or falls, the mercury level in the cistern changes in the opposite direction, and unless this change be taken into account the readings of the mercury height in the tube will not represent the actual pressure of the air. In the *Fortin barometer* (Fig. 15) this is done by making the *cistern adjustable*, so that the surface of mercury therein can always be brought into contact with the *ivory point* which forms the extremity of the scale. In the *Kew pattern barometer* (Fig. 16)

the *cistern is rigid*, but the change of level in the cistern is allowed for in the graduation of the scale.

Transport and Installation of Barometer.—Barometers must be very carefully handled so as to avoid breakage or admission of air into the tube. **A BAROMETER MUST NEVER BE SHIFTED BY THE OBSERVER UNLESS AUTHORITY AND INSTRUCTIONS FOR DOING SO HAVE PREVIOUSLY BEEN RECEIVED FROM METEOROLOGICAL DEPARTMENT.** Usually an Inspector is sent by the Meteorological Department to install a new barometer or to shift the position of the existing barometer. The following instructions are given in case the Observer is asked to shift the barometer in extraordinary circumstances.

How to carry a Fortin Barometer.—Barometers should always be carried with the *cistern end upwards*. Before shifting a *Fortin* Barometer the instructions below should be followed *strictly* in the order in which they are given :—

1st. Screw in the *plunger* P at the bottom of the cistern (C) until the *mercury surface is flush with the boxwood* carrying the ivory point.

2nd. Slowly tighten the three screws S_1, S_2, S_3 (Fig. 15) on the top of the cistern by inserting a small iron nail through the holes at the screw heads. Give a small equal turn to all the screws, one after the other, until they are fairly tight. Do not tighten the screws too much, or the glass of the cistern will crack. Also close the cap of the air vent if there is any.

3rd. Unscrew the three radial screws R_1, R_2, R_3 of the bottom ring R so as to allow the foot of the barometer to pass through the ring.

4th. Remove the *locking screw* L from the peg from which the barometer is suspended.

5th. Hold the barometer firmly in your right hand just *below* the attached thermometer and lift it clear of the peg and the bottom ring with your left hand.

6th. Gradually tilt the barometer held in both hands. The tilting must be *very slow and gentle ;* otherwise the mercury will rise suddenly in the glass tube and may hit its closed end so hard as to smash it. Slow down the tilting more and more as the mercury rises in the tube until a *click* is heard. It is very

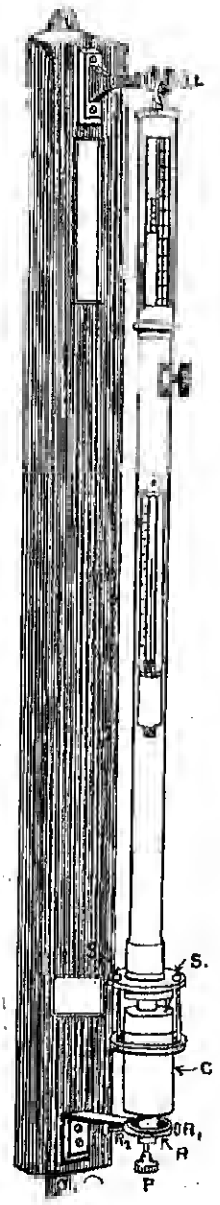


FIG. 15
FORTIN BAROMETER

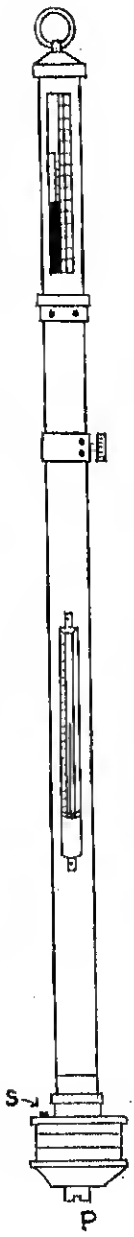


FIG. 16
KEW BAROMETER

important to note whether the barometer makes a 'click' when it is being inverted, *because this sharp sound indicates that the vacuum is free from air.* When the mercury has completely filled the glass tube, invert the barometer fully with the cistern end upwards. The barometer can now be carried about safely in this inverted position.

In order to re-install the barometer for use, the above operations have to be gone through in the reversed order.

How to carry a Kew pattern barometer.—Before shifting a Kew pattern barometer, follow the instructions below *strictly* in the order in which they are given.—

1st. Tighten up the small screw S (Fig. 16) on the lid of the cistern by means of a screw-driver.

2nd. Tilt the barometer slowly until the mercury fills the glass tube completely and a *click* is heard. Then invert the barometer fully with cistern end upwards.

3rd. While in this inverted position, remove the large screw P from the bottom of the cistern by means of the key belonging to this instrument. Take care not to allow drops of mercury to escape from the threads of the screw. Collect all such mercury drops and pour into the cistern after taking out the screw.

4th. Now screw in the *travelling screw* in place of the screw P. The *leather pad* at the end of the travelling screw closes the mouth of the glass tube.

The barometer can now be carried about with the cistern upwards.

In order to set up the barometer for use, follow the above operations in the reversed order. Holding the barometer cistern upwards, take out the travelling screw and put the screw P in its place with care not to *spill any mercury or allow drops to escape.* Then it is advisable to give the cistern several sharp taps so that air bubbles, which sometimes enter the tube in spite of the latter being closed, may be removed. Now turn the barometer right way up and fix it on to the peg. Finally, do not forget to loosen the small screw S in the lid of the cistern which allows access to air.

NOTE.—In all these operations, care must be taken not to loosen the screwed parts of which the cistern is constructed.

Exposure and Suspension.—A barometer should be mounted in a room not subject to sudden or great changes of temperature. It should

be in good light but the sun must never shine on it directly. *A position near a window, against a wall of an unheated and little used room having a north aspect is very suitable.*

A backboard is usually used for the suspension of a barometer. To facilitate readings, a piece of *white* paper or *opal glass* is fixed immediately behind the part of the tube at which the readings are taken, and if the barometer is of the Fortin type, another piece is placed behind the cistern. It is desirable to erect the instrument at such a height that the Observer can read the vernier comfortably when standing upright. The following instructions should be observed in mounting a barometer.—

1st. Select a suitable place on the wall of a room which satisfies all the necessary conditions of exposure of a barometer.

2nd. Draw a horizontal pencil line on the wall about 5 ft. above the floor and another line below, the distance between the two lines being equal to the length of the barometer backboard.

3rd. Insert three wall-plugs about 6″ apart on each line and fix on to them two wooden planks 2′×3″×1″ by means of 2½″-screws. See that the wooden planks are parallel and horizontal and that the lower one is fixed vertically below the top one.

4th. Fix five 1-inch screws on the top plank, 4 inches apart, leaving two inches space on each side of the plank and mount the backboard of the station barometer on the third screw.

5th. Verify with a plumb line whether the backboard is hanging *vertically*. Then screw it tight to the bottom plank.

6th Now mount the barometer on the peg attached to the backboard and see that the foot of the barometer hangs freely inside the bottom ring.

7th. Then tighten the screw of the peg and *gently* adjust the three radial screws of the bottom ring until they just touch the foot of the barometer and clamp it in a *truly vertical position.*

If the station has a spare barometer, it can be mounted on another screw of the top plank. The other three screws should be kept in readiness for the inspection barometers.

31. EXPOSURE OF THERMOMETERS.—The essential conditions for the exposure of thermometers are that air should have free access to the

bulbs of the thermometers, but the sun should not shine or rain fall on them.

(i) **Description of the Stevenson screen.**—These conditions are fulfilled by mounting the thermometers in a screen of the approved pattern (**Fig. 17**) called the **Stevenson screen.** It is a double louvred box ; its internal dimensions being :— length 30 inches, width 18 inches and height 19 inches ; with

Fig. 17.

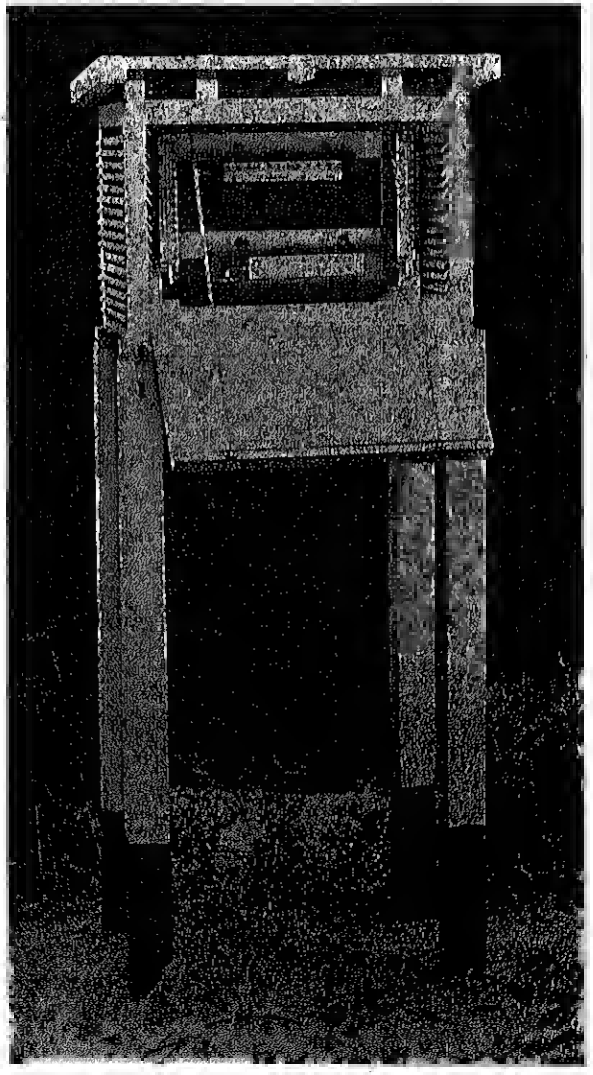


FIG. 17. STEVENSON SCREEN.

a double roof, the upper one projecting 2 inches beyond the sides of the screen and sloping from front to back. The front of the screen is hinged as a door and can be opened downwards.

(ii) **Choice of Site for the Stevenson screen.**—The site should be upon *generally level* ground. A station on a steep slope or in a hollow is subject to exceptional meteorological conditions. The ideal site for a thermometer screen is a level piece of ground covered with short grass in the shape of a rectangle, 30 ft. by 16 ft. (*see* Fig. 18). It is always desirable that the raingauge and the screen should be placed on the same plot. *The distance of the raingauge or the screen from any object should be at least twice the height of the object.*

(iii) **Erection of the Stevenson screen.**—The Stevenson screen is to be erected on four stout wooden posts (*see* Fig. 18) with its *door opening to the north*, and at such a height that the *bulbs of the wet and dry bulb thermometers shall be exactly 4 feet above the ground.*

The tarred ends of the four posts should be buried vertically in concrete under the surface of the ground so that the tops of the posts are 4 ft. above the ground level. The distance between the posts (marked 1, 2, 3 and 4) should be such that the corner legs of the screen (also marked 1, 2, 3 and 4) fit in easily in the sockets at the top of the corresponding posts. The number on a leg of the screen and the corresponding number on the post should face in the same direction.

Before fixing the posts permanently by ramming the concrete, make sure that they are *perfectly vertical* and their tops are four feet above the ground and that the door of the Screen mounted on the posts faces north. Then fix the legs of the Screen in the sockets by means of three-inch screws.

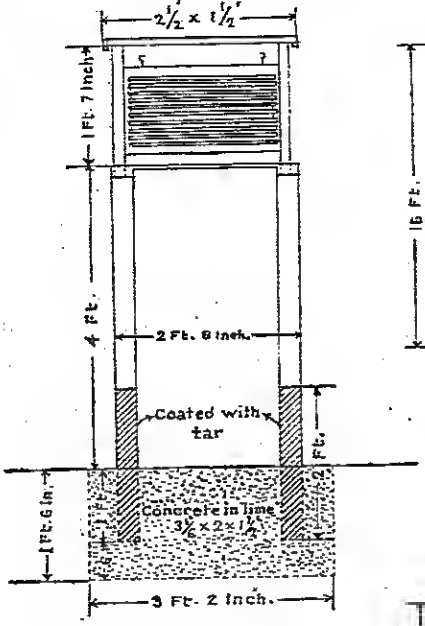
32. **RAINGAUGE.**—

(i) **Description.**—The raingauge which is prescribed by the Government of India for use at rainfall measuring stations in India is known as the "Symon's Raingauge." It (Fig. 19) consists of (*c*) the base which is fixed to the foundation, (*b*) the cylindrical body and (*a*) the funnel provided with a brass

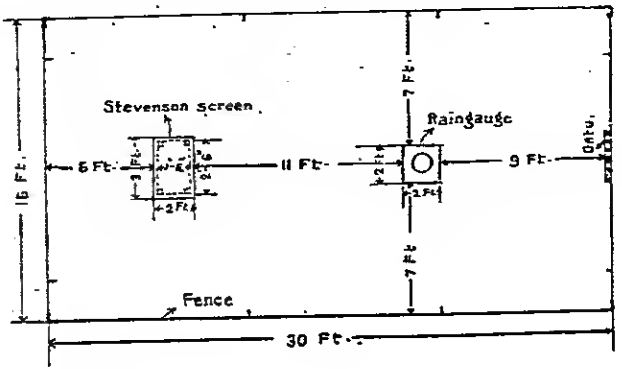
PLAN

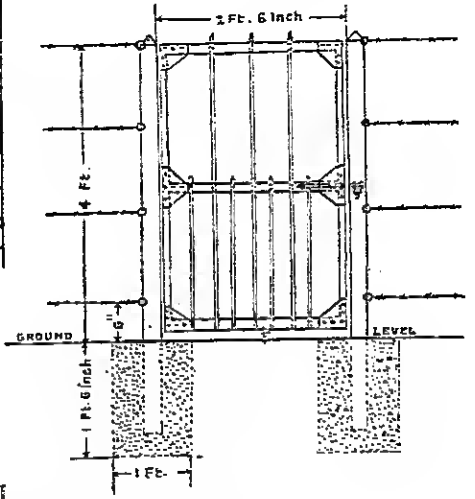
OF STEVENSON SCREEN AND RAINGAUGE IN POSITION AND THE STANDARD BARBED WIRE FENCE.

FIG. 18



ELEVATION OF STEVENSON SCREEN.





ELEVATION OF GATE

ELEVATION OF BARBED WIREFENCE.

Fig. 18.

rim, which should be *truly circular*, and be exactly 5 inches in diameter.

Fig. 19.

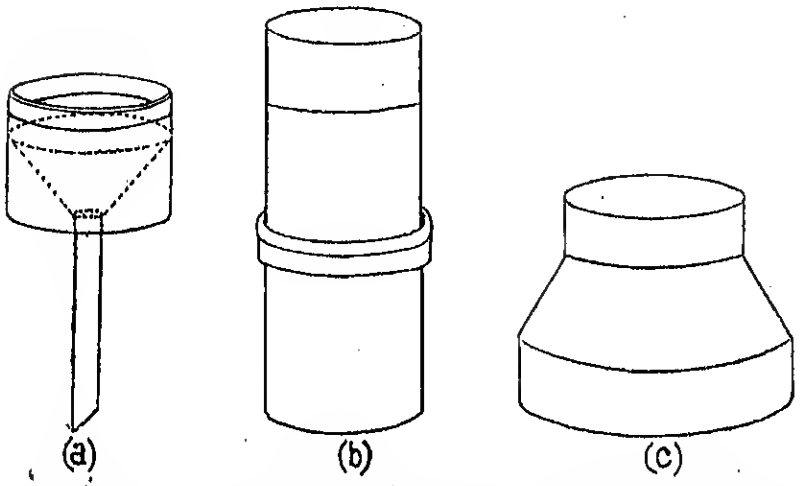


FIG. 19. RAINGAUGE: (a) Funnel, (b) Body, (c) Base.

The rain falling into the funnel collects into a vessel kept inside the cylindrical body and is measured by means of a *special* measure glass graduated in tenths and hundredths of an inch.

(ii) **Exposure.**—The amount of precipitation collected in a raingauge depends to a considerable extent on its exposure and great care must be exercised in selecting a suitable site. The raingauge should be set on a *level ground* away from trees, buildings and other obstructions and not upon a slope or terrace. *The distance between the raingauge and the nearest object should not be less than twice the height of that object above the rim of the gauge.* Subject to the above condition, a position sheltered from wind is preferable to an exposed one.

In order that observations at different stations may be comparable, the exposure must be as uniform as possible at all stations. The rule which must be strictly adhered to in the erection of a raingauge is that its rim should be exactly horizontal and **one foot above the ground level.** The site of the Stevenson screen should be so chosen that the raingauge can be placed on that plot of ground at a distance of 12 feet from the Screen to its south.

(iii) **Erection.**—The raingauge should be erected on a masonry or concrete foundation $2' \times 2' \times 2'$ sunk into the ground (Fig. 20). Into this foundation the base of the gauge is cemented, so that the rim of the gauge is exactly one foot above ground level. When setting the gauge great care must be taken to ensure that the rim is *perfectly level*. It is also important that the gauge is firmly secured to the foundation so that it cannot be blown over by a gale or displaced when the funnel is removed for measuring rainfall.

Fig. 20.

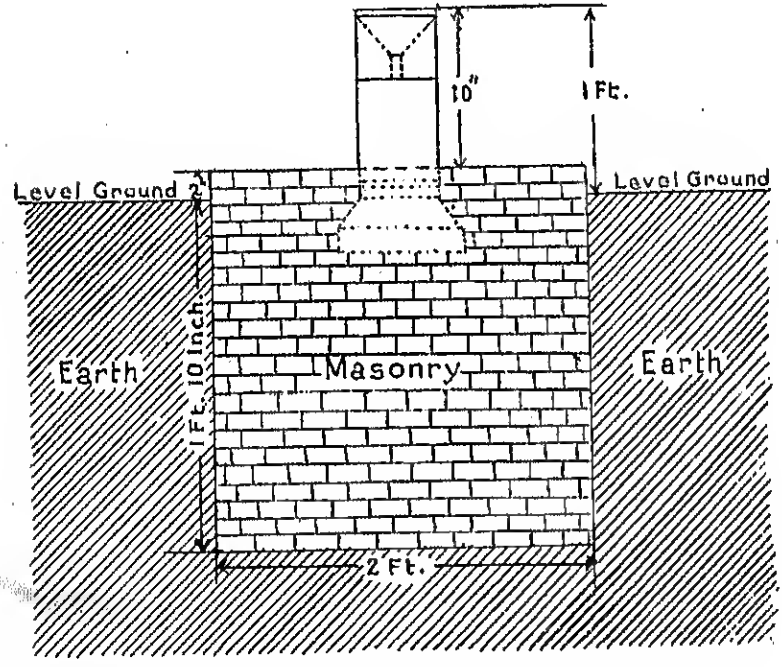


FIG. 20. ERECTION OF RAINGAUGE

33. **WIND INSTRUMENTS.**—

Wind-Vane.—The wind-vane (Fig. 11) is a balanced lever which turns freely about a vertical axis. In the most common type, one end of the lever exposes a broad surface to the wind, whilst the other end is narrow and points to the direction from which the wind blows. Under this moveable system is fixed a rigid cross, the arms of which are set to the four cardinal directions,—North, East, South and West. Some wind-

vanes are provided with eight direction-indicators, N, NE, E, etc.

The most important point in the erection of a wind-vane is that its *direction-indicators are set correctly*. This can be done by means of a magnetic compass. The N-indicator should be set to *true north* and not to the magnetic north. In India the magnetic north lies to the *east or west of the true north* at an angle of the order of 3°. This angle varies from place to place, and should be accurately determined from a map showing *Lines of Equal Magnetic Declination*.

NOTE.—While using a magnetic compass for the determination of direction care should be taken to ensure that *no iron or steel objects* are present near the compass. Even the presence of iron nails on the support on which the compass is placed, or of knives or keys in the Observer's pocket, may give rise to serious errors in the determination of direction.

Anemometer.—The instrument (Fig. 12) consists of four hemispherical cups attached to the ends of two crossed metal arms. The cross is pivoted at its central point to a vertical spindle passing through a brass tube attached to the anemometer box. The difference of pressure of the wind on the convex and concave surfaces of the cups causes the cross to rotate along with the spindle. The foot of the spindle rests on a *steel ball* placed inside a hollow at the base of the box. The rotation of the upright spindle is transferred by means of a gear to a recording apparatus called the *Cyclometer*.

Exposure of wind Instruments.—The site for the wind instruments should be selected in a *perfectly open situation* as far away from tall trees, buildings and other obstacles as possible so that winds from *all* directions may strike the anemometer cups with full force. The standard exposure of the instruments is at the height of 33 ft. above the ground.

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